June 2001

MONITORING THE MIGRATIONS OF WILD SNAKE RIVER SPRING/SUMMER CHINOOK SALMON SMOLTS

Annual Report 1999

DOE/BP-19164-2

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Monitoring the Migrations of Wild Snake River Spring/Summer Chinook Salmon Smolts, 1999

Stephen Achord, Gordon A. Axel, Eric E. Hockersmith, Benjamin P. Sandford,
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Report of Research by

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to

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EXECUTIVE SUMMARY

This report details the 1999 results from the ongoing monitoring of the migration behavior of wild spring/summer chinook salmon smolts in the Snake River Basin. The report also discusses trends in the cumulative data from Oregon and Idaho streams since 1989.

The project was initiated after 3 years of detection data (1989-1991) from passive integrated transponder tags (PIT-tags) had shown distinct differences in migration patterns between wild and hatchery fish. Data showing these patterns originated from tagging and interrogation operations begun in 1988 to evaluate a smolt transportation program conducted by the National Marine Fisheries Service (NMFS) for the U.S. Army Corps of Engineers.

In 1991, the Bonneville Power Administration began a cooperative effort with NMFS to expand tagging and interrogation of wild fish for this project. Project goals were to characterize the outmigration timing of these fish, to determine whether consistent migration patterns emerged, and to investigate the influence of environmental factors on the timing and distribution of these migrations.

In 1992, the Oregon Department of Fish and Wildlife (ODFW) began an independent program of PIT tagging wild chinook salmon parr in the Grande Ronde and Imnaha River Basins in northeast Oregon. Since then, ODFW has reported all tagging, detection, and timing information on fish from these streams. However, with ODFW concurrence, NMFS will continue to report arrival timing of these fish at Lower Granite Dam.

We continued to tag fish from Idaho after 1992. Principal results from our tagging and interrogation during 1998-1999 are enumerated below.

1) In July and August 1998, we PIT tagged and released 9,931 wild chinook salmon parr in 13 streams of Idaho.

2) Average overall observed mortality from collection, handling, tagging, and after a 24-hour holding period was 1.5%.

3) In 1999, the estimated survival to Lower Granite Dam from parr to smolt averaged 20.5% (range 11.1 to 46.7% depending on stream of origin).

4) Fish that were larger at release were detected at a significantly higher rate the following spring and summer than their smaller cohorts ($P < 0.001$).

5) Fish that migrated through the dams in April and May 1999 were significantly larger at release than fish that migrated after May ($P < 0.001$).

6) Detections of all wild spring/summer chinook salmon smolts (from 17 streams in Idaho and Oregon) at Lower Granite Dam began in late-March, coincidental with high flows. Flows and detections moderated in early April, then detections increased as flows increased from mid- to late-April, peaking in late April under moderate-to-high flows. Detections then peaked again in late May under high peak flows.

7) In 1999, we experienced different climatic conditions than in all previous migration years. In late winter, a near record snow pack in the Snake River Basin resulted in high flows during early spring (late March); however, the ensuing flows were moderated by very dry and cold conditions during the remaining spring and early summer. Fluctuating, medium-to-high flows throughout the spring moved the wild fish through Lower Granite Dam as observed in warmer years, with 50% passing by 3 May and 90% passing by 28 May.

Over the years, migration timing patterns from early to late spring have emerged at Lower Granite Dam for some stocks. Annual climatic conditions appear related to the passage distribution (10th, 50th, 90th percentile passage) shifts in these individual stocks observed over the years.

This study examines the annual migration timing at Lower Granite Dam of individual stocks to determine similarities or differences between years. With 10 years of data for South Fork of the Salmon River and 11 years of data for Secesh River, 95% confidence intervals for the 10th, 50th, and 90th passage percentile dates are 13-25 April, 4-14 May, and 4-16 June for South Fork of the Salmon River fish and 10-19 April, 22 April-1 May, and 23 May-15 June for Secesh River fish.

We have observed a 2- to 3-week shift in timing of combined wild stocks passing Lower Granite Dam between relatively warm and relatively cold years. In the warm years of 1990, 1992, 1994, and 1998, the median passage date at the dam was between 29 April and 4 May, and 90% of all wild fish passed by the end of May. In the cold years of 1989, 1991, and 1993, median passage did not occur until mid-May, and the 90th percentile had not passed until mid-June (except during high flows in 1993, when the 90th percentile passed by the end of May).

In 1995, weather conditions in late winter and early spring were moderate compared to those of the previous 6 years, and we observed intermediate passage timing at the dam relative to previous study years, with the median and 90th percentile passage occurring on 9 May and 5 June, respectively. In 1996 and 1997, too few Idaho fish were detected to make meaningful comparisons of timing with other years.

CONTENTS

INTRODUCTION

Background

In 1988, the National Marine Fisheries Service (NMFS) began a cooperative study with the U.S. Army Corps of Engineers to mark wild Snake River spring and summer chinook salmon parr with passive integrated transponder (PIT) tags for transportation research. This project continued through mid-1991, with migrating smolts monitored as they passed Lower Granite, Little Goose, and McNary Dams during spring and summer 1989-1991 (Matthews et al. 1990, 1992; Achord et al. 1992, 1996b, 2000).

Information from these 3 years of study demonstrated that the migration timing of wild stocks through Lower Granite Dam differs among stream of origin and also differs from the migration timing of hatchery-reared fish. Migrations of wild spring chinook salmon were consistently later and more protracted, and exhibited more variable timing patterns over the 3 years, than those of their hatchery-reared counterparts. In contrast, the migrations of wild summer chinook salmon during these same years were earlier, though also more protracted, than those of their hatchery counterparts.

The present study began in mid-1991, when NMFS and the Bonneville Power Administration (BPA) began a cooperative ongoing project to monitor the migrations of wild chinook salmon smolts (Achord et al. 1994). During 1992, the first year of monitoring under the project, warm weather and high water-temperatures in late winter and spring appeared to elicit an earlier migration timing for all wild smolts than observed in the previous 3 years. Also, most wild summer chinook salmon smolts migrated earlier than wild spring chinook salmon smolts. However, consistent with observations from the previous 3 years, all wild stocks exhibited protracted and variable migration timing at Lower Granite Dam.

Details of the results from each study year (1992-1998) are presented in the series of annual reports under BPA Project number 91028. All reports in this series bear the same title and are available on the internet at http://www.efw.bpa.gov (Navigation links to the reports are as follows: Fish and Wildlife, Reports and Publications, Downstream Migration and Water Budget).

Project Goals

Prior to 1992, decisions on dam operations and use of stored water relied on recoveries of branded hatchery fish, index counts at traps and dams, and flow patterns at the dams. The advent of PIT-tag technology has provided the opportunity to precisely track the smolt migrations of many wild stocks as they pass through the hydroelectric complex and other monitoring sites on their way to the ocean. In 1992, the PIT tag

allowed a more complete approach, with the addition of data from several wild spring and summer chinook salmon stocks at Lower Granite Dam.

We initiated development of a database on wild fish, addressing several goals of the Columbia River Basin Fish and Wildlife Program of the Pacific Northwest Electric Power Planning Council and Conservation Act (1980). Section 304(d) of the program states, "The monitoring program will provide information on the migrational characteristics of the various stocks of salmon and steelhead within the Columbia Basin." Further, Section 201(b) urges conservation of genetic diversity, which will be possible only if wild stocks are preserved.

The goals of this ongoing study are 1) to characterize the migration timing of different stocks of wild Snake River spring/summer chinook salmon smolts at dams on the Snake and Columbia Rivers, 2) to determine whether consistent migration patterns are apparent, and 3) to determine what environmental factors influence these patterns.

This report provides information on PIT tagging of wild chinook salmon parr in 1998 and the subsequent monitoring of these fish. Fish were monitored as they migrated through juvenile migrant traps in 1998 and 1999 as well as through interrogation systems at Lower Granite, Little Goose, Lower Monumental, McNary, John Day, and Bonneville Dams during 1999.

METHODS

Fish Collection and Tagging

In 1992, Oregon Department of Fish and Wildlife (ODFW) began PIT tagging wild chinook salmon parr in the Grande Ronde and Imnaha River drainages in northeast Oregon. All tagging, detection, and timing information for fish from these streams in 1998-1999 will be reported by ODFW. However, with ODFW's concurrence, NMFS will continue to report the timing at Lower Granite Dam of summer-tagged fish from these Oregon streams.

Collection and PIT-tagging procedures described by Matthews et al. (1990) and Achord et al. (1994; 1995a,b) were used for our field work in summer 1998.

Juvenile Migrant Traps

During fall 1998 and spring 1999, juvenile migrant fish traps were operated at Knox Bridge on the South Fork of the Salmon River, at the South Fork of the Salmon River below its confluence with the Secesh River, at Lake Creek, near Chinook Campground on the Secesh River, at Marsh Creek, and near the Sawtooth Hatchery on the upper Salmon River (Fig. 1). Also during spring 1999, migrant traps were operated on the lower Salmon River near Whitebird, Idaho, and on the Snake River at Lewiston, Idaho (Fig. 1). Traps were operated by the Nez Perce Tribe and the Idaho Department of Fish and Game.

Interrogation at Dams

During spring and summer 1999, surviving chinook salmon PIT tagged for this study migrated volitionally downstream through hydroelectric dams on the Snake and Columbia Rivers. Of the eight dams the smolts passed, the following six were equipped with smolt collection and/or PIT-tag interrogation systems: Lower Granite, Little Goose, and Lower Monumental Dams on the Snake River (Fig. 1), and McNary, John Day, and Bonneville Dams on the Columbia River.

At these six dams, all smolts guided from turbine intakes into juvenile bypass systems were electronically monitored for PIT tags. The PIT-tag interrogation systems were the same as those described by Prentice et al. (1990). Dates and times to the nearest second were automatically recorded on a computer as PIT-tagged fish passed each detector. Detection data were transferred once daily to the mainframe computer operated by the Pacific States Marine Fisheries Commission in Portland, Oregon.

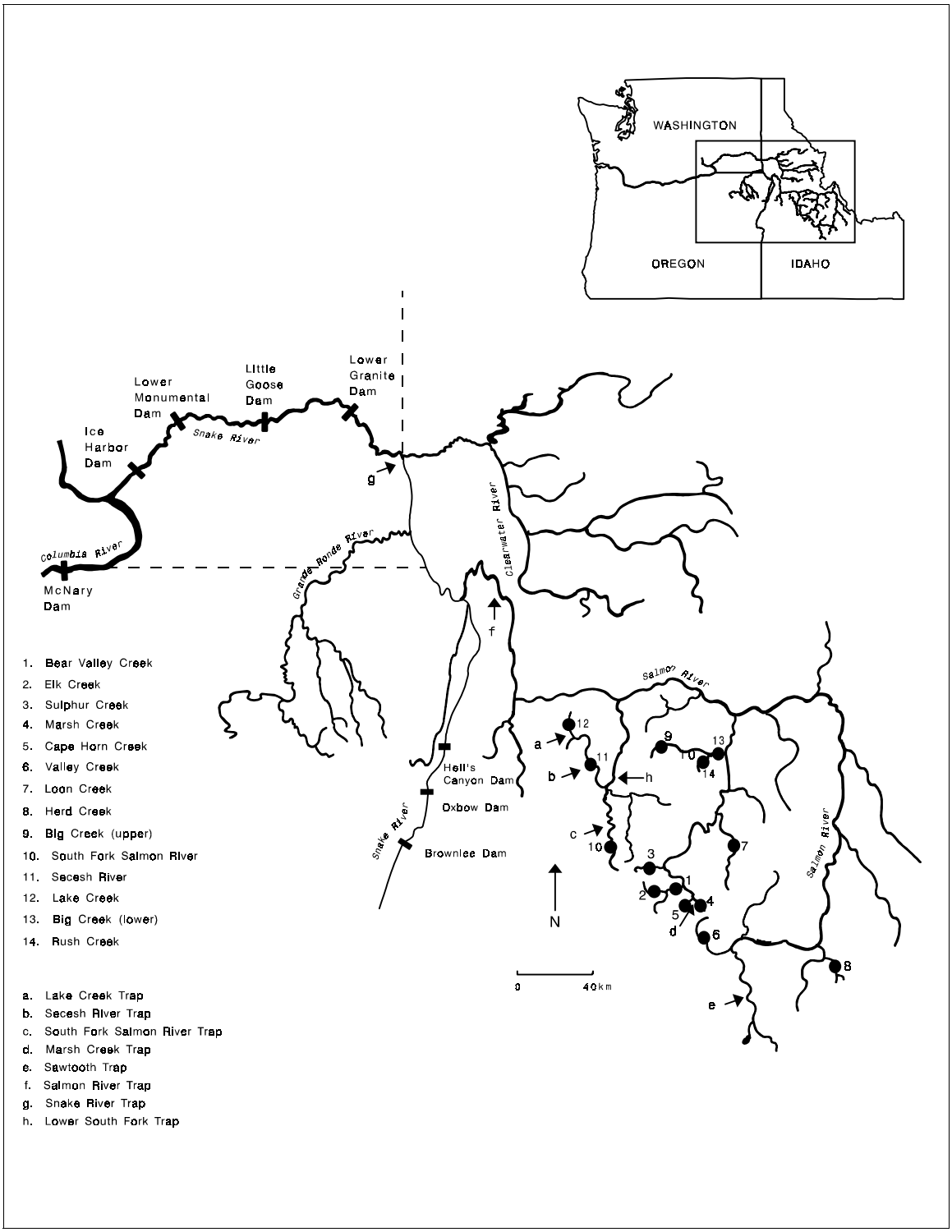


Figure 1. Study area where wild spring/summer chinook salmon parr were PIT tagged during summer 1998.

Migration Timing

During the years of spill from 1993 to 1997, migration timing at each interrogation dam was analyzed based on first-time detection numbers expanded relative to the proportion of daily spill (Achord et al. 1995a,b; 1996b, 1997, 1998). This produced a spill-adjusted or indexed number of PIT-tagged fish passing each dam daily for individual or combined populations. Since 1998, within-season migration timing at Lower Granite Dam has been based on daily detection numbers expanded relative to estimated daily detection probabilities. Detection probabilities were calculated using the methods of Sandford and Smith (in press) to provide an estimate of the number of PIT-tagged wild spring/summer chinook salmon smolts that passed the dam each day. At interrogation dams below Lower Granite Dam, migration timing was based simply on first-time detections, without adjustments.

Migration timing at all dams was calculated by totaling the number of detections in 3-day intervals and dividing by total detections during the season (expanded numbers were used only for detections at Lower Granite Dam). This method was applied to detection data for fish from individual and combined streams. Migration timing at Lower Granite Dam was calculated for smolts from individual streams in Idaho and Oregon, while migration timing at all interrogation dams was calculated for smolts from all Idaho streams combined at all interrogation dams except John Day and Bonneville Dams.

There was no straightforward way to compare within-season passage timing dates among stocks from different streams to discern statistically significant differences in arrival timing at Lower Granite Dam. Therefore, we used an approach analogous to analysis of variance with multiple comparisons between the 10th, 50th (median), and 90th percentile passage timings at the dam. Bootstrap methods were used to calculate estimates of the standard error for each statistic (Efron and Tibshirani 1993). A "representative" estimate of variance for each statistic was then calculated as the median of the standard errors for all 17 streams. The Student-Newmann-Keuls (SNK) multiple comparison method ($\alpha = 0.05$) was used to make comparisons between streams for each statistic (Petersen 1985).

Environmental Information

Environmental information was collected from monitoring systems at the following locations: 1) in Marsh Creek, 2) in Valley Creek, 3) near Sawtooth Hatchery in the upper Salmon River, 4) in the South Fork of the Salmon River by Knox Bridge, and 5) near the Chinook Campground in the Secesh River. All monitoring systems except the system at Valley Creek were adjacent to juvenile migrant fish traps.

RESULTS

Fish Collection and Tagging

From 29 July to 31 August 1998, we collected 11,512 wild chinook salmon parr in Idaho over a distance of about 40 stream kilometers (Table 1; Appendix Table 1). Of these fish, 9,931 were PIT tagged and released back into the streams; the remainder were not tagged because of size, injury, precocious maturation, or because they were collected for genetic studies. Numbers released per stream ranged from 27 in Rush Creek to 1,029 in Loon Creek. Fork lengths of tagged and released wild fish ranged from 52 to 97 mm (mean 68 mm) and weights ranged from 1.5 to 11.8 g (mean 4.2 g).

Other than chinook salmon parr, sculpin were the most abundant species observed during electrofishing operations (Table 2). However, these numbers do not represent total abundances of fish in the areas of collection.

Mortality associated with collection and tagging procedures was low, and 24-hour tag loss was zero (Table 3 and Appendix Table 2). Average collection mortality was 1.4%, and average tagging and 24-hour delayed mortality was 0.1%. The average overall observed mortality was 1.5%.

Detections at Traps

A total of 87 PIT-tagged wild spring/summer chinook salmon from the South Fork of the Salmon River were detected at the Knox Bridge juvenile migrant fish trap in fall 1998 and spring 1999. Of these, 84 were recaptured, measured, and re-released at the trap in the fall. They had grown an average of 2.9 mm in length (range 0-9 mm) over an average of 19 days (range 1-49 days). Three wild fish from the summer tagging were detected at the trap in spring 1999. They had grown an average of 9.7 mm (range 7-13 mm) over an average of 220 days (range 209-243 days). Two summer-tagged parr were detected at the trap on the lower South Fork of the Salmon River. Both were detected in the fall and had grown an average of 5 mm (range 4-6 mm) over an average of 40 days (range 32-48 days).

A total of 62 summer PIT-tagged fish from Lake Creek were detected at the Lake Creek trap during fall 1998; none were reported in spring 1999. They had grown an average of 3 mm (range 0-9 mm) over an average of 25 days (range 2-57 days). A total of 22 summer-tagged fish were detected at the Secesh River trap, which is a few kilometers below the Lake Creek trap. All were detected in fall 1998 and had grown an average of 2 mm (range 0-7 mm), over an average of 22 days (range 3-57 days).

A total of 25 summer PIT-tagged fish from Marsh Creek were detected at the Marsh Creek trap in fall 1998. They had grown an average of 5 mm (range 0-10 mm), over an average of 33 days (range 1-89 days).

Table 1. Summary of collection, PIT-tagging, and release of wild chinook salmon with average fork lengths, weights, and approximate distances covered in Idaho streams during July and August 1998.

Tagging location	Number collected	Number released	Average length of tagged fish (mm)	Average weight of tagged fish (g)	Kilometers covered in streams
Bear Valley Creek	849	820	64.8	3.6	3
Elk Creek	717	700	67.6	3.9	4
Sulphur Creek	498	443	62.6	3.2	3
Marsh Creek	837	770	69.9	4.2	3
Cape Horn Creek	396	270	61.3	2.8	2
Valley Creek	1,138	1,001	68.8	4.2	7
Loon Creek	1,107	1,029	66.9	3.9	2
Herd Creek	1,034	959	70.7	4.7	4
Big Creek (upper)	993	960	67.2	4.2	3
S. Fork Salmon River	1,703	1,004	62.9	3.5	2
Secesh River	1,069	936	65.1	3.4	2
Lake Creek	668	545	67.1	3.8	1
Big Creek (lower)	475	467	80.6	6.9	3
Rush Creek	28	27	75.8	6.3	1
Totals	11,512	9,931	68.0	4.2	40

Table 2. Summary of species other than chinook salmon observed during collection operations in Idaho in July and August 1998.

Streams	Steelhead	Un-identified fry	Brook trout	Cutthroat trout	Bull trout	Sculpin	Dace	Sucker	Whitefish	Shiner
Bear Valley Creek	174	9	284	0	0	864	6	0	7	0
Elk Creek	57	0	592	0	0	878	4	1	38	0
Sulphur Creek	128	3	0	0	4	1,492	0	0	0	0
Marsh Creek	99	18	1,186	0	1	774	0	0	9	0
Cape Horn Creek	13	0	64	0	0	158	0	0	0	0
Valley Creek	329	53	834	0	1	3,667	590	75	121	5
Loon Creek	200	1,357	0	0	1	386	0	0	31	0
Herd Creek	79	105	0	0	1	260	7	0	4	0
Big Creek (upper)	170	9	473	0	2	1,677	0	0	0	0
S. Fork Salmon River	269	61	45	0	1	276	12	0	4	0
Secesh River	165	143	15	0	9	488	147	0	0	0
Lake Creek	60	58	54	0	13	387	2	0	16	0
Big Creek (lower)	603[a]	1,026[a]	0	8	1	387[a]	80	4	0	0
Rush Creek	- -	- -	0	0	2	- -	0	0	0	0
Totals	2,346	2,842	3,547	8	36	11,694	848	80	230	5

[a] Includes some fish from Rush Creek.

Table 3. Mortality and tag loss for wild chinook salmon parr collected and PIT tagged in Idaho, August 1998.

Tagging location	Mortality (%)				24-hour tag loss (%)
	Collection	Tagging	24-hour	Overall	
Bear Valley Creek	0.9	0.1	0.0	1.1	0.0
Elk Creek	1.5	0.0	0.0	1.5	0.0
Sulphur Creek	0.6	0.2	0.0	0.8	0.0
Marsh Creek	0.5	0.0	0.0	0.5	0.0
Cape Horn Creek	0.8	0.0	0.0	0.8	0.0
Valley Creek	1.9	0.1	0.0	2.0	0.0
Loon Creek	3.2	0.4	0.0	3.5	0.0
Herd Creek	3.9	0.1	0.0	4.0	0.0
Big Creek (upper)	1.4	0.1	0.0	1.5	0.0
S. F. Salmon River	0.4	0.1	0.0	0.4	0.0
Secesh River	0.6	0.1	0.0	0.7	0.0
Lake Creek	0.7	0.0	0.0	0.7	0.0
Big Creek (lower)	1.7	0.0	0.0	1.7	0.0
Rush Creek	3.6	0.0	0.0	3.6	0.0
Averages	1.4	0.1	0.0	1.5	0.0

Eight summer-tagged fish were detected at the Salmon River juvenile migrant fish trap during spring 1999. They had grown an average of 29 mm (range 19-48 mm) over an average of 226 days (range 202-257 days). Six summer-tagged fish were detected at the Snake River trap in spring, 1999. They had grown an average of 42 mm (range 33-59 mm) over an average of 268 days (range 247-294 days).

Detections at Dams

Based on expanded detections at Lower Granite Dam from 26 March to 8 July 1999 (2,039 fish), survival from parr to smolt averaged 20.5% (range 11.1 to 46.7%) (Table 4, Appendix Tables 3-16). An additional 1,263 first-time detections were recorded at the lower five dams (Table 4, Appendix Tables 3-16) and were used for evaluations of migrational timing. Total first-time detections at Lower Granite Dam (548) were combined with total first-time detections at the five lower dams (1,263)(Table 4, Appendix Table 17), and the sum was compared to the estimated number of fish that arrived at Lower Granite Dam (2,039). Based on this comparison, an estimated 11.2% of these wild fish from Idaho passed through the hydropower system undetected.

For parr tagged in Idaho, average fork length at release was 68 mm. However, the average fork length at release was 69 mm of those fish detected the following spring at the dams. These length differences were significant (chi-square, $P < 0.001$). The release-length distribution of detected fish was also significantly different than that of all released fish in all length categories except 65-69 mm ($P < 0.04$)(Fig. 2).

We also found a significant difference in fork lengths at time of release for fish that migrated through Lower Granite Dam in April and May compared to fish that migrated after May ($P < 0.001$). Fish migrating through the dam in April and May were on average 5 mm larger when released than fish migrating after May. These data suggest that fish size may influence migration timing or overwintering location with respect to proximity to the first dam.

Table 4. Summary of first-time detections of PIT-tagged wild spring/summer chinook salmon smolts from Idaho at six dams from March to July, 1999. Expanded detections at Lower Granite Dam provide estimates of parr to smolt survival.

Stream	Detections												
	Lower Granite			Little Goose		Lower Monumental		McNary		John Day		Bonneville	
		Expanded											
	Detected	N	%	N	%	N	%	N	%	N	%	N	%
Bear Valley Creek	39	131	16.0	70	8.5	20	2.4	10	1.2	9	1.1	1	0.1
Big Creek (upper)	42	155	16.1	63	6.6	14	1.5	2	0.2	7	0.7	1	0.1
Big Creek (lower)	58	218	46.7	80	17.1	22	4.7	4	0.9	3	0.6	1	0.2
Cape Horn Creek	15	57	21.1	28	10.4	9	3.3	2	0.7	1	0.4	0	0.0
Elk Creek	44	161	23.0	61	8.7	25	3.6	8	1.1	1	0.1	0	0.0
Herd Creek	58	211	22.0	83	8.7	15	1.6	7	0.7	3	0.3	2	0.2
Lake Creek	21	79	14.5	43	7.9	14	2.6	2	0.4	2	0.4	1	0.2
Loon Creek[a]	71	283	27.5	137	13.3	52	5.1	9	0.9	10	1.0	6	0.6
Marsh Creek	58	218	28.3	68	8.8	29	3.8	6	0.8	4	0.5	1	0.1
Rush Creek	1	3	11.1	4	14.8	1	3.7	1	3.7	0	0.0	0	0.0
S. Fork Salmon River	38	142	14.1	44	4.4	21	2.1	4	0.4	1	0.1	1	0.1
Secesh River	36	137	14.6	57	6.1	20	2.1	3	0.3	2	0.2	0	0.0
Sulphur Creek	17	71	16.0	25	5.6	11	2.5	5	1.1	0	0.0	1	0.2
Valley Creek	50	173	17.3	80	8.0	38	3.8	5	0.5	1	0.1	2	0.2
Totals or averages	548	2,039	20.5	843	8.5	291	2.9	68	0.7	44	0.4	17	0.2

[a] One additional fish from this stream was a first-time detection at the PIT-trawl at the mouth of the Columbia River.

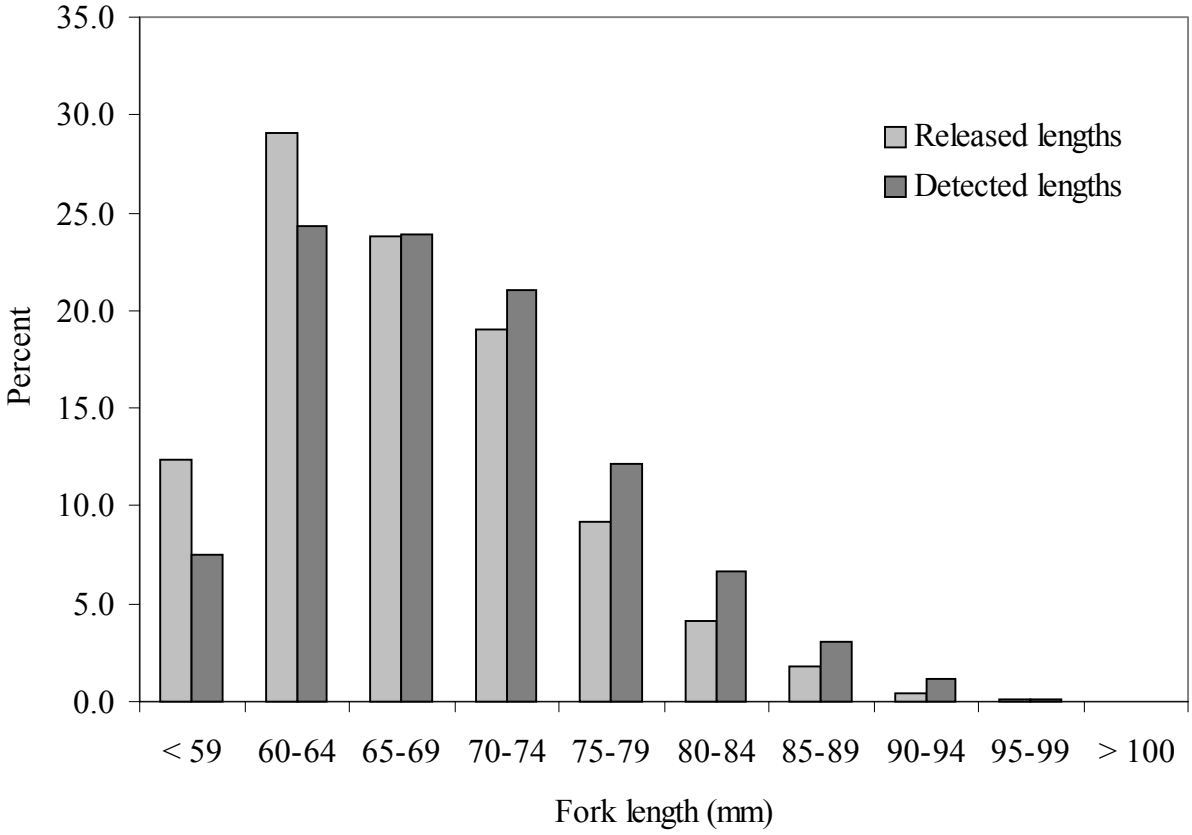


Figure 2. Percent by fork-length increments, of PIT-tagged wild spring/summer chinook salmon parr released in Idaho streams in 1998 and percent of fish detected for these length increments at Lower Granite, Little Goose, Lower Monumental, McNary, John Day, and Bonneville Dams in spring and summer 1999.

Migration Timing

Fish from the Lostine and South Fork of the Salmon Rivers were the first to arrive at Lower Granite Dam (Fig. 3). For the 10th percentile passage distributions at the dam, fish from the Lostine, South Fork of the Salmon, Secesh, and Minam Rivers had significantly earlier timing than fish from the other 13 streams in Idaho and Oregon ($P < 0.05$). The overall 10th percentile passage distributions for fish from all 17 streams ranged from 30 March to 30 April (Table 5).

Fish from the Secesh River, Lake Creek, Big Creek (lower), Herd Creek, and Minam River had significantly earlier 50th percentile passage timing at the dam than fish from Imnaha River, Lostine River, Valley Creek, Big Creek (upper), Loon Creek, Sulphur Creek, Cape Horn Creek, and Catherine Creek ($P < 0.05$).

Fish from Herd Creek had significantly earlier 90th percentile passage timing than fish from the other 16 streams at the dam ($P < 0.05$). Also, fish from Herd Creek, Big Creek (lower), Marsh Creek, Minam River, Secesh River, Imnaha River, Lake Creek, Loon Creek, Lostine River, Sulphur Creek, Cape Horn Creek, and Elk Creek had significantly earlier timing at the dam than fish from Catherine Creek and Valley Creek. Fish from the remaining three streams had intermediate (non-significant) timing at the dam for the 90th percentile passage distributions. The overall 90th percentile passage distributions for fish from all 17 streams ranged from 10 May to 15 June (Table 5).

The middle 80th percentile passage distributions were of significantly shorter duration (20 days) for fish from Herd Creek than for fish from Lake Creek, Big Creek (upper), Elk Creek, Bear Valley Creek, Minam River, Catherine Creek, Secesh River, Valley Creek, Lostine River, and the South Fork Salmon River (37-61 days; $P < 0.05$) (Table 5). The middle 80th percentile passage distributions for fish from the other six streams ranged from 27 to 34 days.

Timing of smolts from individual streams in Idaho is not presented here for Little Goose, Lower Monumental, McNary, John Day, or Bonneville Dams (see Appendix Tables 3-16 for this information).

We combined all detections of wild fish from Idaho streams at each of four collector dams and compared the timing at each dam with river flows during the same periods (Fig. 4). Overall, passage occurred between late March and early July at Lower Granite Dam, with the middle 80% passage occurring from late-April to late-May (Table 6). The peak passage date was 27 April, which coincided with a moderate-high flow period; a lesser peak in passage occurred during peak seasonal flows in late May at the dam (Appendix Table 18).

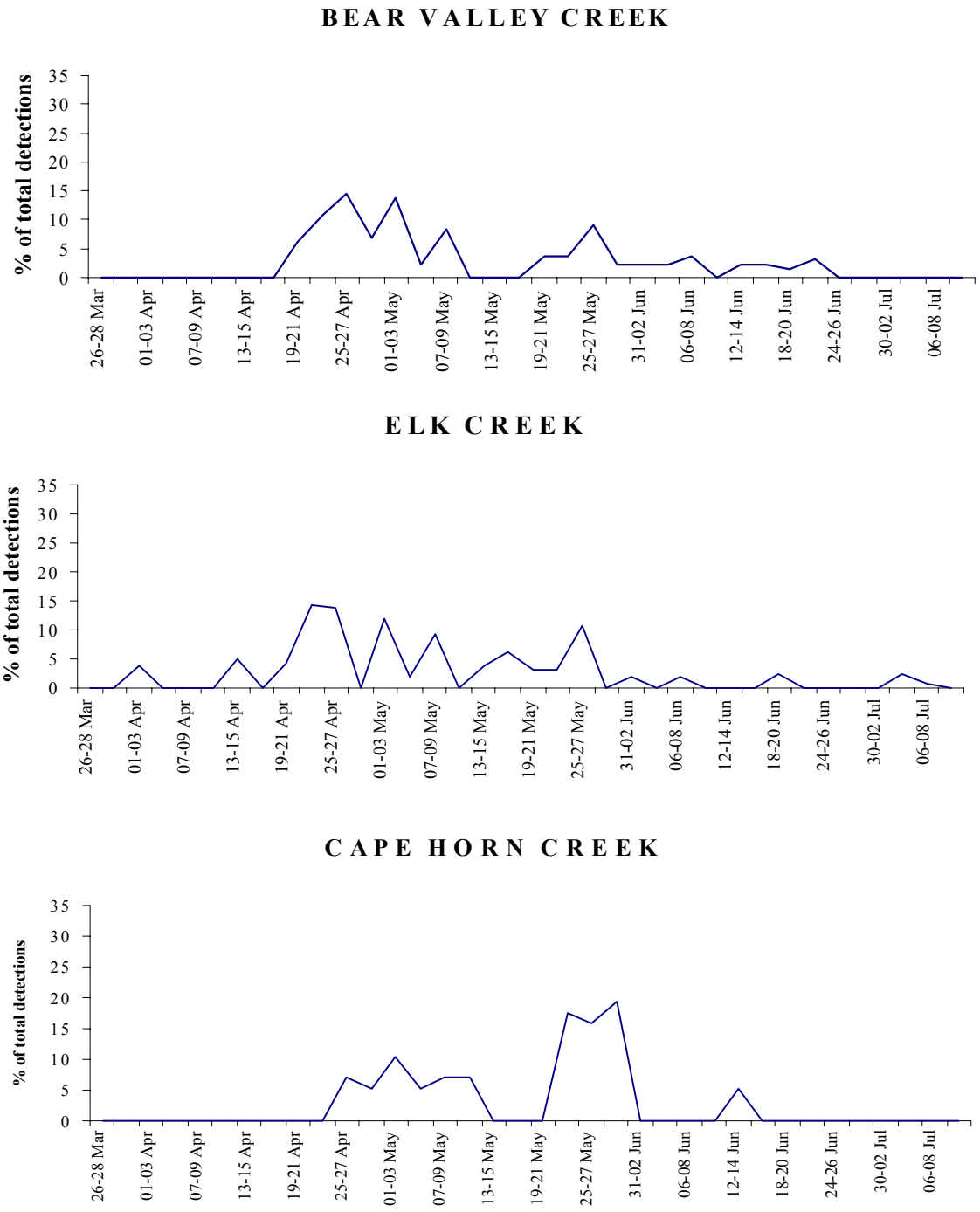


Figure 3. The migration timing (expanded by estimated detection probabilities) at Lower Granite Dam in 1999 of wild spring/summer chinook salmon smolts PIT tagged during summer 1998 in individual streams in Idaho and Oregon.

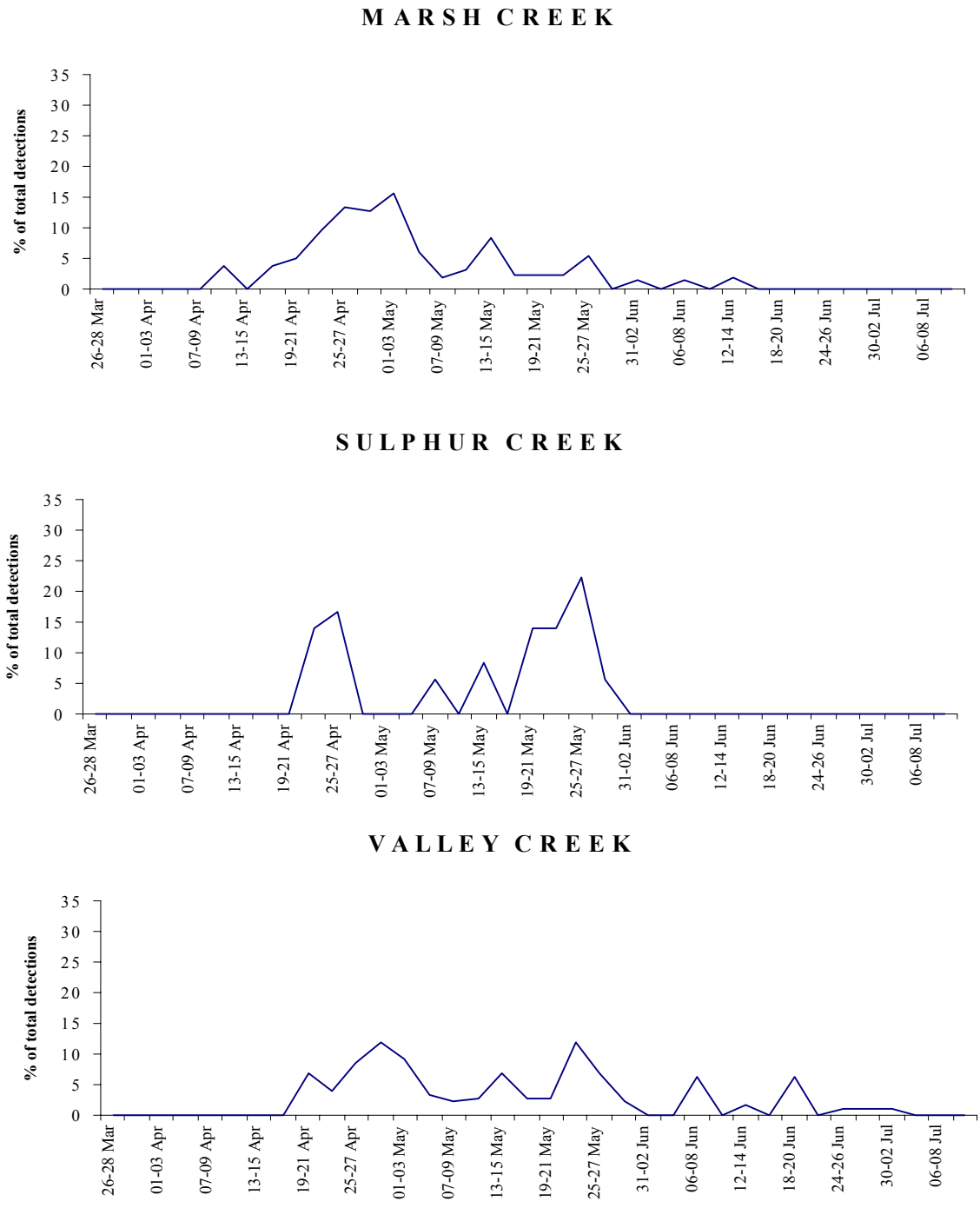
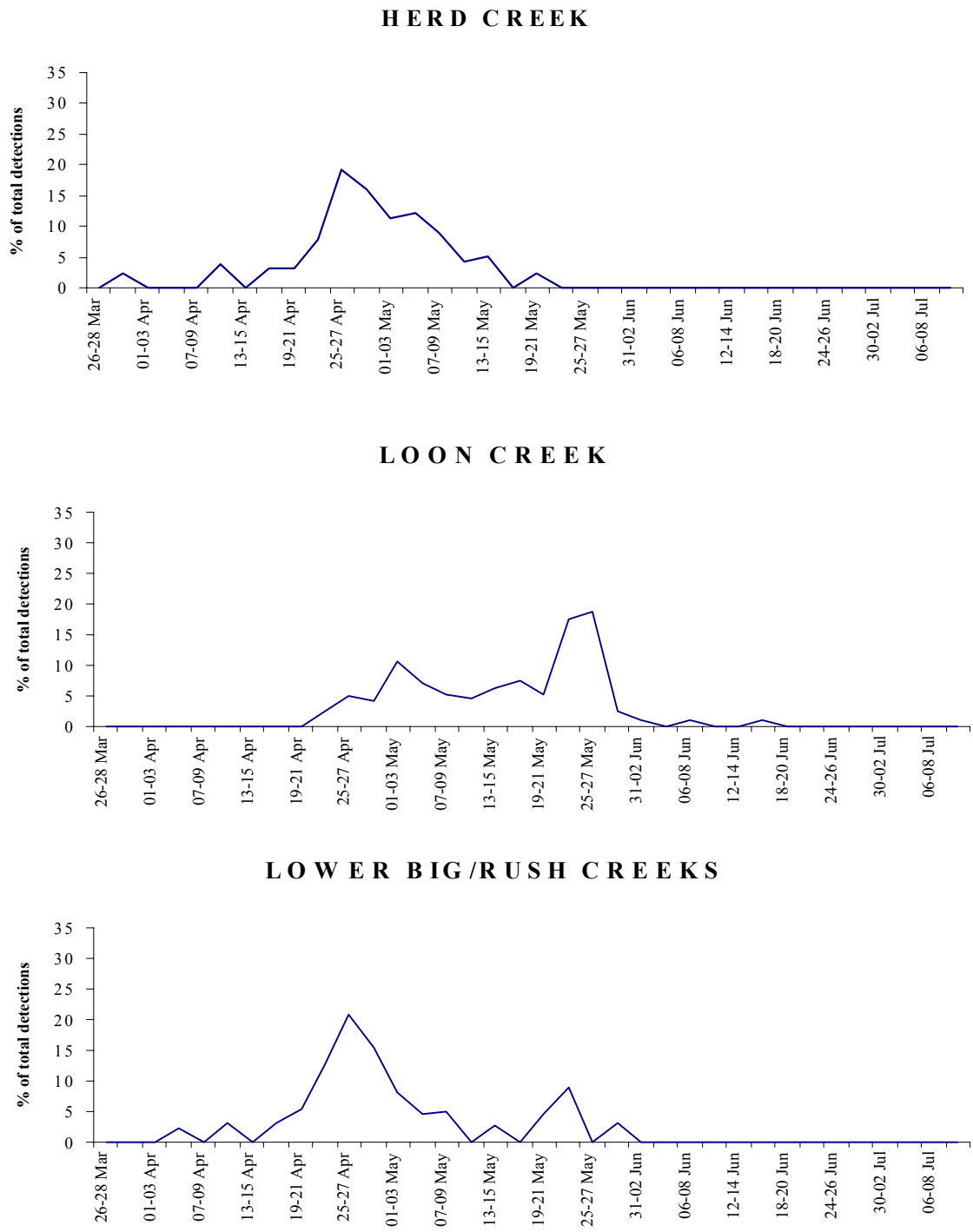


Figure 3. Continued.



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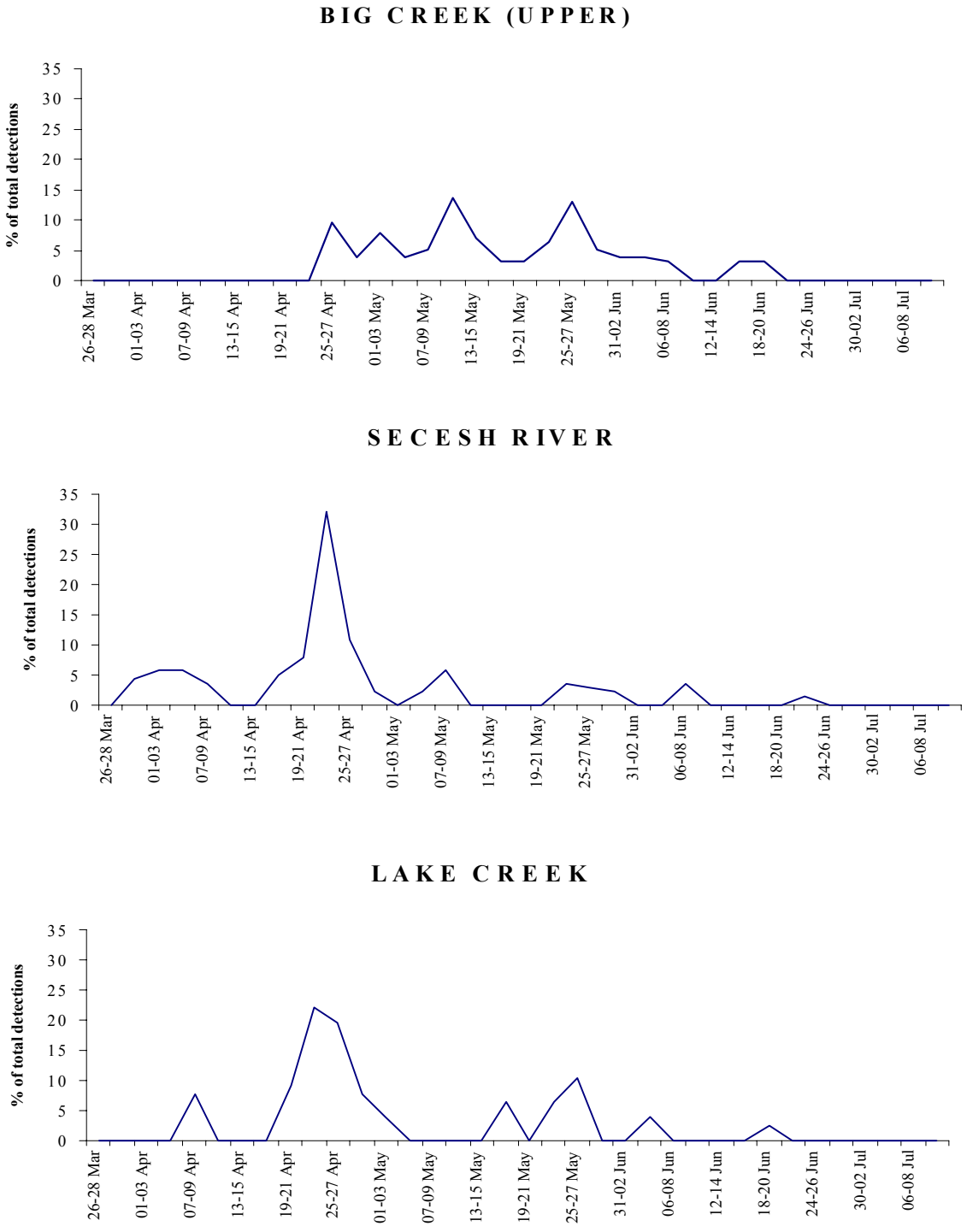

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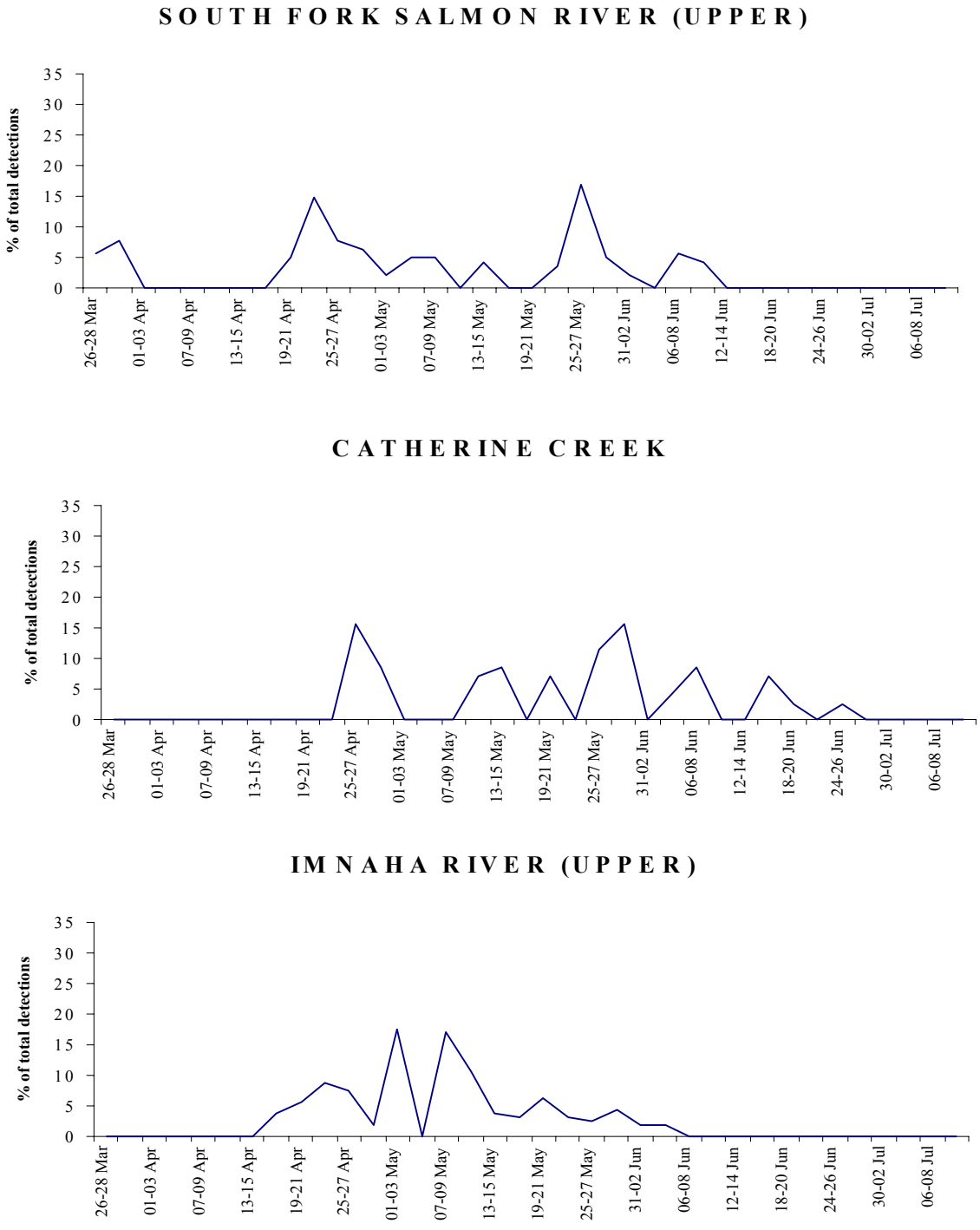

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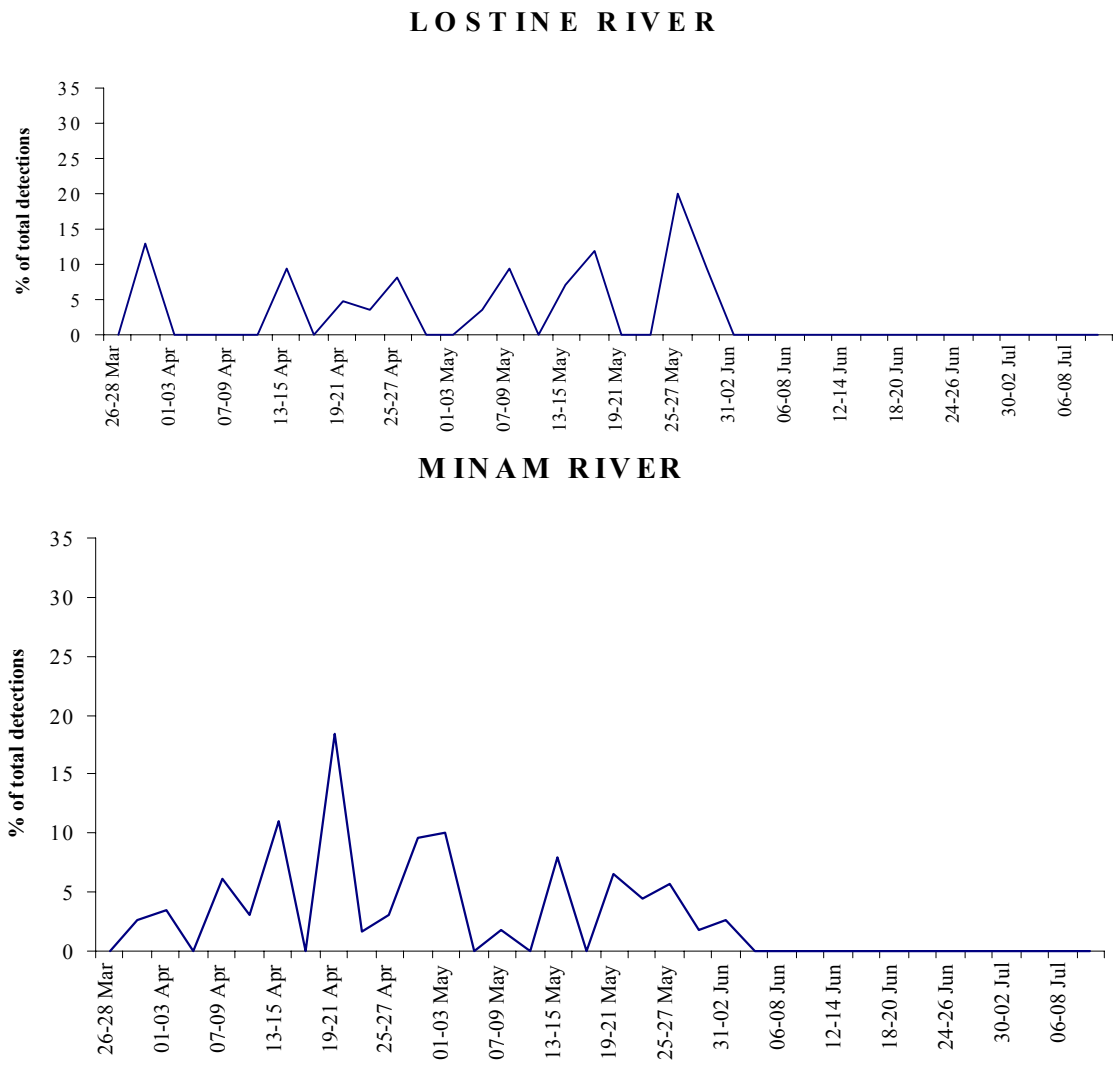

Figure 3. Continued.

Table 5. Historical and 1999 passage dates at Lower Granite Dam for PIT-tagged wild spring/summer chinook salmon smolts from streams in Idaho and Oregon.

Year	Passage dates at Lower Granite Dam			
	10%	50%	90%	Range
		Bear Valley Creek		
1990	19 April	05 May	31 May	11 April-18 July
1991	03 May	20 May	12 June	18 April-23 June
1992	15 April	02 May	24 May	07 April-28 June
1993	29 April	16 May	22 June	22 April-27 July
1994	22 April	06 May	29 May	16 April-15 July
1995	28 April	18 May	12 June	13 April-20 July
1996[a]	----------	----------	----------	----------
1997[a]	----------	----------	----------	----------
1998	25 April	06 May	23 May	31 March-25 June
1999	**23 April**	**03 May**	**07 June**	**20 April-21 June**
		Elk Creek		
1990[b]	----------	----------	----------	----------
1991	03 May	20 May	16 June	25 April-24 June
1992	11 April	30 April	28 May	05 April-17 July
1993	02 May	16 May	11 June	21 April-26 June
1994	23 April	04 May	21 May	18 April-09 July
1995	18 April	11 May	05 June	10 April-09 July
1996[a]	----------	----------	----------	----------
1997[a]	----------	----------	----------	----------
1998	07 April	02 May	15 May	04 April-21 June
1999	**21 April**	**03 May**	**27 May**	**01 April-08 July**
		Sulphur Creek		
1990	18 April	30 April	31 May	11 April-27 June
1991[a]	----------	----------	----------	----------
1992	16 April	03 May	23 May	10 April-01 June
1993	28 April	16 May	12 June	24 April-28 June
1994[a]	----------	----------	----------	----------
1995	02 May	23 May	09 June	11 April-09 July
1996[a]	----------	----------	----------	----------
1997[a]	----------	----------	----------	----------
1998[a]	----------	----------	----------	----------
1999	**24 April**	**19 May**	**27 May**	**22 April-29 May**

Table 5. Continued.

Year	Passage dates at Lower Granite Dam			
	10%	50%	90%	Range
		Cape Horn Creek		
1990[a]	----------	----------	----------	----------
1991	24 April	16 May	28 May	19 April-06 June
1992	12 April	28 April	30 May	10 April-01 June
1993	08 May	19 May	26 June	05 May-01 July
1994[a]	----------	----------	----------	----------
1995	29 April	14 May	19 June	14 April-28 July
1996[a]	----------	----------	----------	----------
1997[a]	----------	----------	----------	----------
1998[a]	----------	----------	----------	----------
1999	**29 April**	**22 May**	**29 May**	**25 April-12 June**
		Camas Creek		
1993	03 May	16 May	27 May	24 April-24 June
1994	30 April	15 May	26 May	24 April-11 July
1995	27 April	12 May	05 June	17 April-11 June
1996[a]	----------	----------	----------	----------
1997[a]	----------	----------	----------	----------
1998[a]	----------	----------	----------	----------
1999[a]	----------	----------	----------	----------
		Marsh Creek		
1990	17 April	29 April	31 May	09 April-01 July
1991	26 April	20 May	09 June	17 April-18 June
1992	17 April	07 May	02 June	10 April-13 July
1993	29 April	15 May	27 May	24 April-10 August
1994	23 April	04 May	18 May	16 April-08 August
1995	17 April	09 May	24 May	11 April-08 July
1996[a]	----------	----------	----------	----------
1997[a]	----------	----------	----------	----------
1998[a]	----------	----------	----------	----------
1999	**21 April**	**01 May**	**25 May**	**11 April-13 June**

Table 5. Continued.

Year	Passage dates at Lower Granite Dam			
	10%	50%	90%	Range
		Valley Creek		
1989	24 April	14 May	12 June	09 April-17 June
1990	16 April	08 May	05 June	12 April-29 June
1991	11 May	20 May	20 June	21 April-13 July
1992	15 April	30 April	27 May	13 April-04 June
1993	30 April	16 May	02 June	24 April-06 June
1994	24 April	04 May	03 June	22 April-09 June
1995	04 May	02 June	08 July	22 April-18 July
1996[a]	----------	----------	----------	----------
1997[a]	----------	----------	----------	----------
1998[a]	----------	----------	----------	----------
1999	**24 April**	**13 May**	**12 June**	**19 April-01 July**
		Loon Creek		
1993	05 May	12 May	17 May	03 May -25 June
1994	29 April	10 May	24 May	22 April-07 June
1995	23 April	11 May	28 May	13 April-07 June
1996[a]	----------	----------	----------	----------
1997[a]	----------	----------	----------	----------
1998[a]	----------	----------	----------	----------
1999	**30 April**	**18 May**	**27 May**	**22 April-16 June**
		East Fork Salmon River		
1989	22 April	03 May	18 May	07 April-08 June
1990[a]	----------	----------	----------	----------
1991	22 April	09 May	26 May	16 April-20 June
1992	13 April	21 April	16 May	10 April-03 June
1993	25 April	06 May	18 May	22 April-01 June
1994	22 April	28 April	17 May	20 April-25 May
1995	14 April	28 April	10 May	11 April-27 May
1996[a]	----------	----------	----------	----------
1997[a]	----------	----------	----------	----------
1998[a]	----------	----------	----------	----------
1999[a]	----------	----------	----------	----------

Table 5. Continued.

Year	Passage dates at Lower Granite Dam			
	10%	50%	90%	Range
		Herd Creek		
1992	14 April	20 April	10 May	13 April-18 May
1993	26 April	30 April	18 May	26 April-31 May
1994[b]	----------	----------	----------	----------
1995	18 April	03 May	14 May	11 April-28 May
1996[a]	----------	----------	----------	----------
1997[a]	----------	----------	----------	----------
1998[a]	----------	----------	----------	----------
1999	**20 April**	**29 April**	**10 May**	**30 March-20 May**
		South Fork Salmon River		
1989	25 April	13 May	14 June	16 April-20 June
1990[a]	----------	----------	----------	----------
1991	20 April	16 May	10 June	17 April-13 July
1992	14 April	29 April	27 May	07 April-27 July
1993	29 April	16 May	02 June	26 April-28 June
1994	27 April	15 May	28 June	22 April-09 July
1995	20 April	10 May	10 June	13 April-13 July
1996	19 April	15 May	09 June	19 April-03 July
1997	13 April	28 April	12 June	07 April-15 June
1998	25 April	12 May	15 June	02 April-07 August
1999	**31 March**	**04 May**	**01 June**	**27 March-11 June**
		Big Creek (upper)		
1990	27 April	30 May	22 June	17 April-18 July
1991	18 May	10 June	26 June	26 April-01 July
1992	22 April	08 May	03 June	15 April-26 June
1993	08 May	18 May	26 May	26 April-15 June
1994	03 May	19 May	19 July	25 April-30 August
1995	05 May	23 May	09 June	02 May-26 June
1996[a]	----------	----------	----------	----------
1997[a]	----------	----------	----------	----------
1998[a]	----------	----------	----------	----------
1999	**28 April**	**14 May**	**03 June**	**25 April-19 June**

Table 5. Continued.

Year	Passage dates at Lower Granite Dam			
	10%	50%	90%	Range
		Big Creek (lower)/Rush Creek		
1993	24 April	29 April	13 May	21 April-16 May
1994	23 April	29 April	11 May	21 April-15 June
1995	19 April	01 May	14 May	11 April-05 June
1996[a]	----------	----------	----------	----------
1997[a]	----------	----------	----------	----------
1998[a]	----------	----------	----------	----------
1999	**19 April**	**28 April**	**23 May**	**04 April-30 May**
		West Fork Chamberlain Creek		
1992[c]	15 April	26 April	03 June	12 April-24 June
1993	28 April	15 May	23 June	23 April-22 July
1994[c]	24 April	01 May	05 July	24 April-04 September
1995[c]	16 April	09 May	20 June	12 April-22 September
1996[a]	----------	----------	----------	----------
1997[a]	----------	----------	----------	----------
1998[a]	----------	----------	----------	----------
1999[a]	----------	----------	----------	----------
		Secesh River		
1989	20 April	27 April	09 June	09 April-19 July
1990	14 April	22 April	07 June	10 April-13 July
1991	20 April	27 April	14 June	13 April-20 July
1992	13 April	29 April	04 June	05 April-03 July
1993	26 April	16 May	16 June	22 April-15 July
1994	22 April	26 April	11 July	21 April-07 August
1995	14 April	01 May	24 May	10 April-10 July
1996	14 April	25 April	29 May	12 April-15 July
1997	10 April	18 April	04 May	04 April-11 July
1998	08 April	24 April	28 May	03 April-06 July
1999	**03 April**	**23 April**	**25 May**	**29 March-21 June**

Table 5. Continued.

Year	Passage dates at Lower Granite Dam			
	10%	50%	90%	Range
		Lake Creek		
1989	23 April	02 May	16 June	12 April-01 July
1990[a]	----------	----------	----------	----------
1991[a]	----------	----------	----------	----------
1992[a]	----------	----------	----------	----------
1993	23 April	09 May	22 June	22 April-25 June
1994	21 April	28 April	19 May	20 April-24 June
1995	17 April	10 May	10 June	14 April-20 July
1996	15 April	21 April	19 May	15 April-02 June
1997	11 April	25 April	02 July	07 April-22 September
1998	04 April	25 April	26 May	02 April-16 July
1999	**20 April**	**26 April**	**27 May**	**08 April-20 June**
		Catherine Creek		
1991	01 May	14 May	08 June	17 April-23 June
1992	16 April	01 May	21 May	09 April-29 June
1993	06 May	18 May	05 June	29 April-26 June
1994	25 April	11 May	20 May	13 April-26 July
1995	01 May	19 May	09 June	26 April-02 July
1996[d]	19 April	13 May	29 May	14 April-14 June
1997	08 May	14 May	01 June	24 April-10 June
1998	28 April	21 May	28 May	24 April-04 June
1999	**26 April**	**25 May**	**15 June**	**26 April-26 June**
		Grande Ronde River (upper)		
1989	12 May	06 June	19 June	27 April-22 July
1990[a]	----------	----------	----------	----------
1991[a]	----------	----------	----------	----------
1992[a]	----------	----------	----------	----------
1993	05 May	16 May	25 May	23 April-20 June
1994	28 April	23 May	07 July	23 April-29 August
1995	27 April	29 May	12 June	12 April-01 July
1996[e]	26 April	17 May	29 May	19 April-06 June
1997[a]	----------	----------	----------	----------
1998[a]	----------	----------	----------	----------
1999[a]	----------	----------	----------	----------

Table 5. Continued.

Year	Passage dates at Lower Granite Dam			
	10%	50%	90%	Range
		Imnaha River (lower)		
1989	11 April	30 April	11 May	04 April-05 June
1990	10 April	18 April	09 May	05 April-27 May
1991	20 April	01 May	13 May	14 April-15 May
1992	10 April	21 April	03 May	06 April-21 May
1993[a]	----------	----------	----------	----------
1994[a]	----------	----------	----------	----------
1995[a]	----------	----------	----------	----------
1996[a]	----------	----------	----------	----------
1997[a]	----------	----------	----------	----------
1998[a]	----------	----------	----------	----------
1999[a]	----------	----------	----------	----------
		Imnaha River (upper)		
1993	24 April	14 May	28 May	15 April-23 June
1994	24 April	08 May	09 June	20 April-11 August
1995	13 April	02 May	03 June	10 April-07 July
1996	16 April	26 April	18 May	14 April-12 June
1997	11 April	19 April	11 May	03 April-02 June
1998	11 April	28 April	13 May	03 April-24 May
1999	**22 April**	**08 May**	**26 May**	**17 April-03 June**
		Lostine River		
1990[b]	----------	----------	----------	----------
1991	29 April	14 May	26 May	20 April-09 July
1992	16 April	30 April	11 May	12 April-02 June
1993	23 April	03 May	17 May	17 April- 01 June
1994	22 April	30 April	16 May	19 April- 07 June
1995	12 April	02 May	17 May	08 April-09 June
1996	23 April	15 May	07 June	17 April-19 June
1997	17 April	28 April	16 May	09 April-21 May
1998[a]	----------	----------	----------	----------
1999	**30 March**	**09 May**	**27 May**	**29 March-29 May**
		Minam River		
1999	**08 April**	**28 April**	**25 May**	**31 March-02 June**

[a] No summer-tagged parr were tagged for this migration year.

[b] Insufficient numbers detected to estimate timing.

[c] Includes fish from Chamberlain Creek.

[d] Includes fish tagged from summer 1995 through spring 1996.

[e] All fish tagged at traps in fall or spring for this migration year.

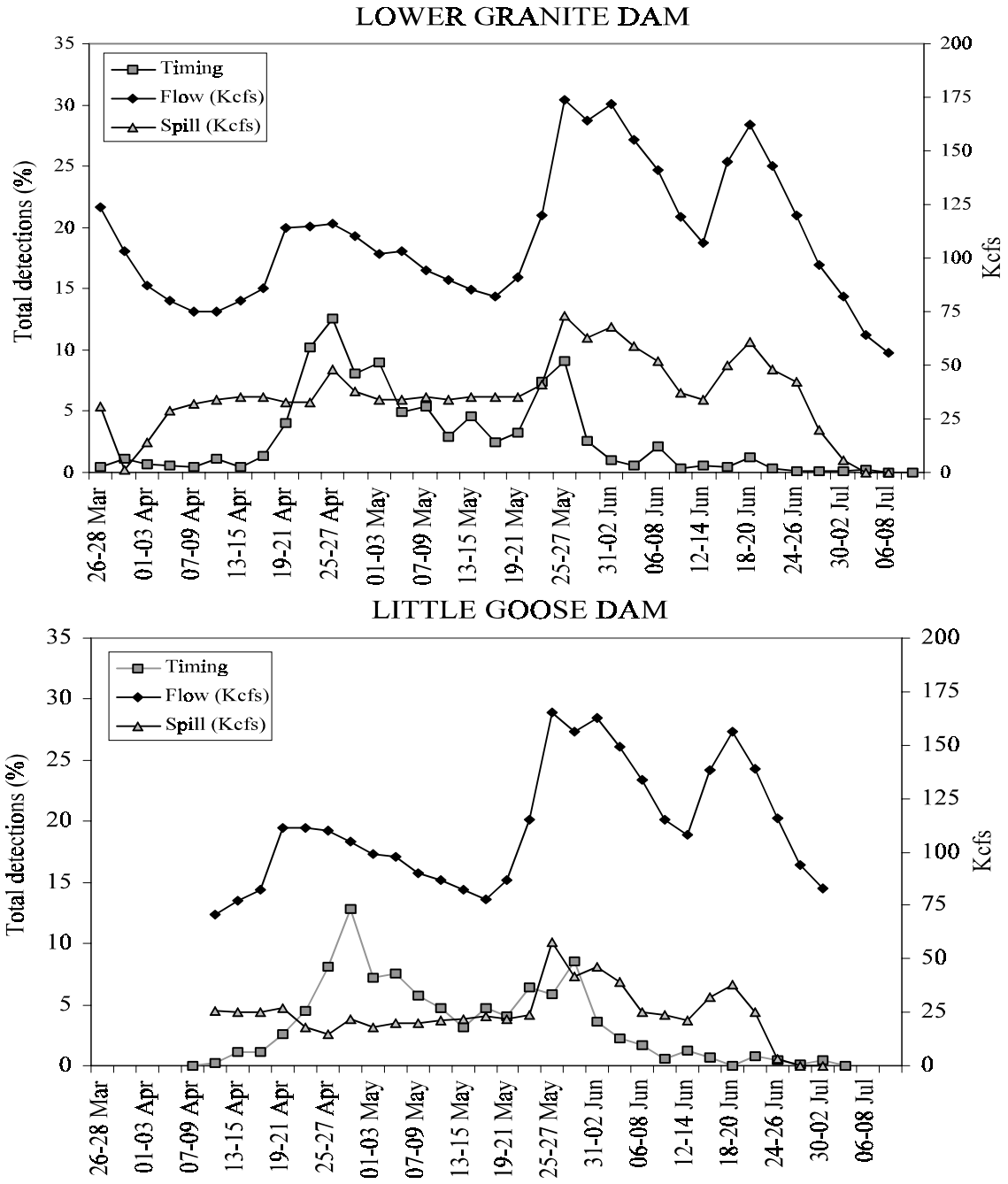

Figure 4. The overall migration timing of PIT-tagged wild spring/summer chinook salmon smolts at Lower Granite, Little Goose, Lower Monumental, and McNary Dams in 1999, with associated river flows and spill at these dams. Data represent detections from 13 Idaho streams combined by 3-day intervals and average river flows and spill at the dams over the same time periods. Detections were expanded by estimated daily detection probabilities at Lower Granite Dam only.

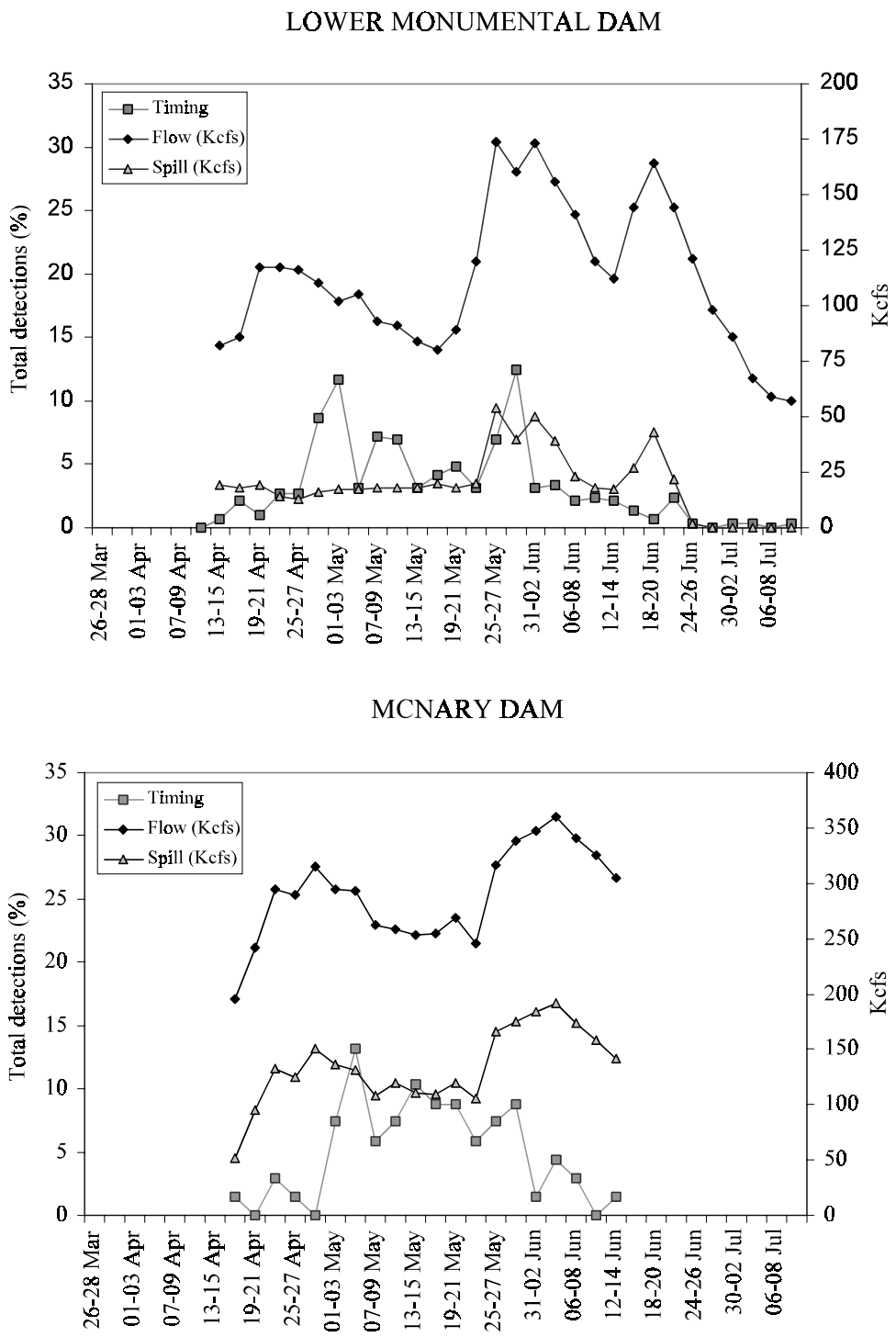

Figure 4. Continued.

Table 6. Passage dates at Lower Granite (expanded), Little Goose, Lower Monumental, McNary, John Day, and Bonneville Dams for combined populations of PIT-tagged wild spring/summer chinook salmon smolts from 13 Idaho streams in 1999.

Site	Passage dates at dams			
	10%	50%	90%	Range
Lower Granite Dam	21 Apr	03 May	27 May	27 Mar-08 Jul
Little Goose Dam	25 Apr	09 May	31 May	11 Apr-01 Jul
Lower Monumental Dam	28 Apr	16 May	09 Jun	13 Apr-10 Jul
McNary Dam	02 May	15 May	30 May	17 Apr-14 Jun
John Day Dam	07 May	01 Jun	12 Jun	25 Apr-22 Jun
Bonneville Dam	19 May	01 Jun	06 Jun	17 May-25 Jun

The middle 80% passage of wild fish at Little Goose, Lower Monumental, and McNary Dams occurred between late April and early June (Table 6). Peak passage periods for fish at Little Goose, Lower Monumental, and McNary Dams coincided with medium-to-high river flows on various dates in late-April and May (Fig. 4 and Appendix Tables 19-21). Passage distributions for fish at John Day and Bonneville Dams are presented in Table 6 and Appendix Tables 3-16; however, too few wild fish were detected at these dams to make meaningful comparisons with flow or other variables.

Environmental Information

Appendix Figures 1-6 compare various water quality parameters to chinook salmon fry, parr, and smolt movements through adjacent traps (Fig. 1) in 1998-1999. Appendix Tables 22-26 provide a summary of environmental information collected from the five environmental monitoring sites from August 1998 to July 1999. Environmental data collected at these sites are available on the internet (Perkins 1998). Appendix Table 27 provides a summary of flow information at five U.S. Geological Survey sites in the Salmon River drainage from August 1998 to July 1999.

DISCUSSION

Mortality rates associated with collection and tagging in 1998 were comparable to those in earlier years (Achord et al. 1992; 1994; 1995a,b; 1996a,b; 1997; 1998; 2000). Of the 84 wild PIT-tagged fish released in summer and detected in fall at the South Fork of the Salmon River trap at Knox Bridge, 19 were detected the next spring at the dams. When we compared this 22.6% detection rate to the overall detection rate (10.9% unadjusted) at the dams for fish tagged in summer in this stream, we see an overall increase of 107.3% in detections. This increase was larger than that observed in 1998 for this site when we observed an 83.2% increase in detections.

Of the 62 summer-tagged fish released and subsequently detected in the fall at the trap on Lake Creek, 16 were detected at the dams. When we compared this 25.8% detection rate to the overall detection rate (15.2%) at the dams for fish tagged in the summer for this stream, we see an overall increase of 69.7% in detections. No detection comparisons from other traps were made due to the low numbers monitored at these traps.

The increases in detection rates at the dams for PIT-tagged fish previously detected at traps in the fall may indicate a higher survival rate for known fall migrants and/or may reflect mortality in the streams over an average of 26 days in the South Fork Salmon River and an average of 25 days in Lake Creek. In the South Fork of the Salmon River, the overall average length of summer-tagged fish was the same as the average length at release for fish detected at the trap in fall. However, fish trapped in fall on Lake Creek averaged 1.3 mm longer at release than the overall average length of summer-tagged fish. This implies that, at least on the South Fork of the Salmon River, size at tagging had little, if any, effect on mortality after release.

Length-distribution curves for data collected over the last 11 years have generally shown that wild fish released and subsequently detected at dams are slightly larger at release than fish that are released but not detected. The reason for this slight difference in detection rates is unknown, but it appears that larger fish survived slightly better and/or were guided slightly better into the collection systems at dams than smaller fish. However, if the fish detected at traps in fall at Marsh Creek in 1994 and at the South Fork of the Salmon River in 1997 and 1998 were a random sample of the population, then survival within the first 1 to 3 months after tagging was not size specific.

Another consistent trend we have observed over the years is the difference in migration timing at dams with respect to size at release. Wild fish migrating in April and May were significantly larger at release than fish migrating after May. This suggests that size is an important factor related to either the initiation of smoltification or other life-history dynamics that affect the migrational timing of wild fish.

Relationships with Flow

In 1999, peak detections of wild fish (Idaho and Oregon) at Lower Granite Dam coincided with increasing flows in late April and detections peaked again in late May coincidental with peak flows (Fig. 5). The moderately high-flow period from 20 April to 5 May helped move most of these fish through the dam. As observed at Lower Granite Dam from 1989 through 1998, peak detections of wild spring/summer chinook salmon smolts from Idaho and Oregon were highly variable and generally independent of river flows before about 9 May. However, in every year peak detections of wild fish from 9 to 31 May coincided with periods of peak flow (Achord et al. 2000). Raymond (1979) showed that peaks in migration for the composite population of spring and summer chinook salmon smolts (mostly wild) passing Ice Harbor Dam from 1964 to 1969 preceded periods of maximum river discharge in most years. During these years, fish passage peaked between 26 April and 13 May. With respect to river flows, our observations matched those of Raymond for wild fish migrating before mid-May.

Climatic Influence

Annual overall climatic variation is emerging as an important factor controlling the overall migrational timing and passage dynamics of wild spring/summer chinook salmon smolts at Lower Granite Dam. In the warm years of 1990, 1992, 1994, and 1998, 50% of all wild fish had passed the dam from 29 April to 4 May, and 90% had passed by the end of May. In the cold years of 1989, 1991, and 1993, 50% of all wild fish had not passed the dam until mid-May, while 90% had not passed until mid-June (except in 1993, when high flows moved 90% through the dam by the end of May).

Within these 7 years, we saw a consistent 2- to 3-week shift in timing of wild fish at the dam between relatively warm and relatively cold years. In 1995, intermediate weather conditions prevailed in late winter and early spring (compared to the previous 6 years), and we observed intermediate passage times of 9 May and 5 June for the 50 and 90% passage dates, respectively, for these combined wild populations.

In 1999, we experienced different climatic conditions than in all previous migration years. In late winter, a near record snow pack in the Snake River Basin resulted in high flows during the early spring (late March); however, the ensuing flows were moderated by very dry and cold conditions during the remaining spring and early summer. Fluctuating medium-to-high flows throughout the spring moved the wild fish through Lower Granite Dam as observed in warmer years, with 50% passing by 3 May and 90% passing by 28 May.

The migration timing of individual wild stocks has been highly variable and usually protracted at Lower Granite Dam. However, some migration timing patterns emerging for some stocks range from early to late spring. Annual climatic conditions appear directly related to the less than 1- to 5-week passage distribution shifts of these stocks observed over the years.

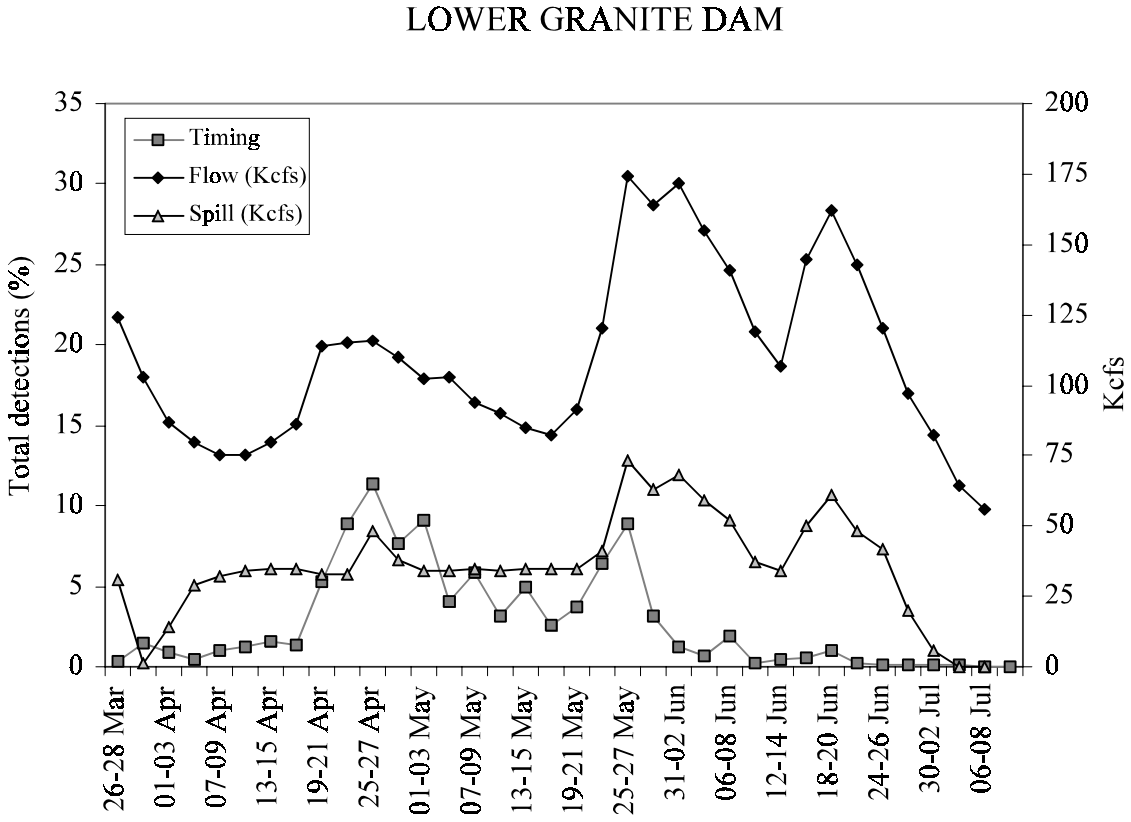

Figure 5. The overall migration timing of PIT-tagged wild spring/summer chinook salmon smolts at Lower Granite Dam in 1999, with associated river flows and spill at this dam. Data represent detections from 13 Idaho and 4 Oregon streams combined by 3-day intervals and average river flows and spill at the dam over the same time periods. Detections were expanded by estimated daily detection probabilities.

Cumulative Data: 1989-1999

Another objective of this study is to examine the migration timing at Lower Granite Dam of individual stocks over a period of years to determine similarities or differences between years. We now have 10 years of data for South Fork of the Salmon River and 11 years of data for Secesh River. The 95% confidence intervals for these data sets fall between 13 and 25 April for the 10th, 4 and 14 May for the 50th, and 4 and 16 June for the 90th percentile passage dates for South Fork of the Salmon River fish. For Secesh River fish, 95% confidence intervals are between 10 and 19 April for the 10th, 22 April and 1 May for the 50th, and 23 May and 15 June for the 90th percentile passage dates. We will include more streams in these analyses as we accrue more years of data.

After examining chinook salmon smolt passage timing at the dams over the last 11 years, it has become clear that flow is only one of several factors that influence passage timing. Other factors, such as annual climatic conditions, water temperature, turbidity, physiological development, variability in stock behavior, fish size, and other yet unknown conditions may equally affect wild smolt passage timing at dams. As additional environmental monitors and traps are installed in study streams, we can more accurately monitor fry, parr, and smolt movements out of rearing areas and examine the relationships between these movements and environmental conditions within the streams. Mapped over time, this information, along with weather and climate data, may prove useful in predicting when different wild stocks will arrive at the first dam.

ACKNOWLEDGMENTS

We thank Neil N. Paasch, Kenneth W. McIntyre, Jonathan H. Kohr, and Douglas M. Marsh for their excellent assistance in collecting and PIT tagging fish for this study. Also, thanks are tendered to personnel from Idaho Department of Fish and Game and the Nez Perce Tribe for providing data from trapping operations in natal rearing areas.

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APPENDIX

Data Figures and Tables

Appendix Table 1. Summary of tagging dates and numbers of wild chinook salmon parr collected, PIT tagged and released in various Idaho streams during 1998 with their minimum, maximum, and average lengths and weights.

Stream	Tagging dates	Number collected	Number tagged	Number released	Length (mm)		Weight (g)	
					Range	Average	Range	Average
Bear Valley Creek	29-30 Jul	849	821	820	52-88	64.8	1.8-8.0	3.6
Elk Creek	30 Jul-01 Aug	717	700	700	54-84	67.6	1.7-7.1	3.9
Sulphur Creek	03-04 Aug	498	444	443	53-80	62.6	1.5-6.9	3.2
Marsh Creek	07-08 Aug	837	770	770	54-92	69.9	2.1-8.7	4.2
Cape Horn Creek	08 Aug	396	270	270	53-84	61.3	1.8-8.5	2.8
Valley Creek	10-12 Aug	1,138	1,002	1,001	55-93	68.8	1.7-9.9	4.2
Loon Creek	14-15 Aug	1,107	1,033	1,029	54-90	66.9	1.8-9.2	3.9
Herd Creek	17-18 Aug	1,034	960	959	55-97	70.7	1.7-10.1	4.7
Big Creek (upper)	20-21 Aug	993	961	960	55-87	67.2	2.0-9.1	4.2
S. F. Salmon River	23-24 Aug	1,703	1,005	1,004	52-82	62.9	1.6-8.3	3.5
Secesh River	26-27 Aug	1,069	937	936	52-87	65.1	1.9-7.2	3.4
Lake Creek	28 Aug	668	545	545	53-86	67.1	1.8-8.3	3.8
Big Creek (lower)	30-31 Aug	475	467	467	60-96	80.6	2.6-11.8	6.9
Rush Creek	31 Aug	28	27	27	68-85	75.8	4.4-8.8	6.3
Totals or averages	---	11,512	9,942	9,931	52-97	68.0	1.5-11.8	4.2

Appendix Table 2. A summary of observed total mortality for PIT tagged wild chinook salmon parr collected from Idaho streams during July and August 1998.

Stream	Number collected	Number tagged	Number rejected	Percent rejected (%)	Observed total mortality			
					Collection	Tagging	Total	%
Bear Valley Creek	849	821	28	3.3	8	1	9	1.1
Elk Creek	717	700	17	2.4	11	0	11	1.5
Sulphur Creek	498	444	54	10.8	3	1	4	0.8
Marsh Creek	837	770	67	8.0	4	0	4	0.5
Cape Horn Creek	396	270	26	6.6	3	0	3	0.8
Valley Creek	1,138	1,002	136	12.0	22	1	23	2.0
Loon Creek	1,107	1,033	74	6.7	35	4	39	3.5
Herd Creek	1,034	960	74	7.2	40	1	41	4.0
Big Creek (upper)	993	961	32	3.2	14	1	15	1.5
S. F. Salmon River	1,703	1,005	698	41.0	6	1	7	0.4
Secesh River	1,069	937	132	12.3	6	1	7	0.7
Lake Creek	668	545	23	3.4	5	0	5	0.7
Big Creek (lower)	475	467	8	1.7	8	0	8	1.7
Rush Creek	28	27	1	3.6	1	0	1	3.6
Totals	11,512	9,942	1,370	11.9	166	11	177	1.5

Appendix Table 3. Detections of PIT-tagged smolts by date at three Snake River dams and three Columbia River dams for wild chinook salmon from the Secesh River, 1999.

Tagging site: Secesh River Release date: 26-27 Aug 1998
Release site: Secesh River Number released: 936
Release River Kilometer(s) above Lower Granite Dam: 429-431

Detection date	Lower Granite		First Detections				
	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
29 Mar	1	6					
03 Apr	1	8					
05 Apr	1	2					
06 Apr	1	6					
09 Apr	1	5					
11 Apr			1				
12 Apr			1				
14 Apr			2				
17 Apr			1	1			
18 Apr	1	7		1			
19 Apr							
20 Apr	1	4	1				
21 Apr	2	7	1				
22 Apr	3	10	4				
23 Apr	8	27	1				
24 Apr	2	7	1	2			
25 Apr	2	11	1	1			
26 Apr	2	4	4	1			
27 Apr			7	1			
28 Apr			3				
29 Apr	1	3	7	1			
30 Apr			3	1			
01 May			2	2			
02 May				2			
03 May			1	1			
04 May			1		1		
06 May	1	3	1				
07 May			1				
08 May	1	4					
09 May	1	4					
11 May			1				
16 May			2		1		
17 May			1				
18 May				1			
23 May	1	5	1	1			
24 May			1				
25 May	1	4	1		1		
28 May			1	1			

Appendix Table 3. Continued.

Detection date	Lower Granite		First Detections				
	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
29 May				1			
30 May	1	3	1	1			
31 May			2				
02 Jun			1				
07 Jun	2	5					
08 Jun							
12 Jun						1	
15 Jun				1			
16 Jun			1				
18 Jun						1	
21 Jun	1	2					
Totals	36	137	57	20	3	2	0

Appendix Table 4. Detections of PIT-tagged smolts by date at three Snake River dams and three Columbia River dams for wild chinook salmon from Lake Creek, 1999.

Tagging site: Lake Creek Release date: 28 Aug 1998
Release site: Lake Creek Number released: 545
Release River Kilometer(s) above Lower Granite Dam: 451-452

Detection date	Lower Granite		First Detections				
	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
08 Apr	1	6					
14 Apr			1				
18 Apr			1				
19 Apr			1				
20 Apr	1	4					
21 Apr	1	3	1				
22 Apr	2	7	2				
23 Apr	1	3	1				
24 Apr	2	7		2			
25 Apr	1	4		2			
26 Apr	2	7	1				
27 Apr	1	4	6				
28 Apr	1	3	3	1			
29 Apr			5	1			
30 Apr	1	3	3	1			
01 May			3				
02 May	1	3		1	1		
03 May			2				
04 May						1	
05 May			1				
06 May				2		1	
08 May			1				
16 May					1		
18 May	1	5					
22 May			1				
23 May	1	5					1
24 May			1				
25 May	1	4					
26 May			1				
27 May	1	4	1				
30 May			1				
31 May			1				
01 Jun			2				
03 Jun			1	1			
05 Jun	1	3	1	1			
17 Jun				1			
20 Jun	1	2					
01 Jul			1				
04 Jul				1			
Totals	21	79	43	14	2	2	1

Appendix Table 5. Detections of PIT-tagged smolts by date at three Snake River dams and three Columbia River dams for wild chinook salmon from Bear Valley Creek, 1999.

Tagging site: Bear Valley Creek Release date: 29-30 July 1998
Release site: Bear Valley Creek Number released: 820
Release River Kilometer(s) above Lower Granite Dam: 631-634

	Lower Granite		First Detections				
Detection date	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
13 Apr			1	1			
14 Apr			1				
15 Apr			1				
17 Apr					1		
18 Apr			1				
20 Apr	2	8	1	1			
21 Apr			4				
22 Apr	1	3	2				
23 Apr	1	7	1				
24 Apr	2	4			1		
25 Apr	1	4	2			1	
26 Apr	1	4					
27 Apr	3	11	1			1	
28 Apr			3				
29 Apr	2	6	1	1			
30 Apr	1	3	1	2			
01 May	1	3					
02 May	3	9	1				
03 May	2	6	1				
04 May	1	3	2		1		
05 May			1				
06 May			1				
07 May	1	4	3	1			
08 May	2	7	1				
09 May			2			1	
10 May			1				
11 May				1			
12 May			1	1			
13 May			1	1			
14 May			1		1		
16 May			1		1		
18 May			3				
19 May			1				
20 May	1	5	2				
21 May				1			
22 May	1	5	1	1		1	
23 May			3		1		

Appendix Table 5. Continued.

Detection date	Lower Granite		First Detections				
	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
25 May			2	2			
26 May	2	8	1				
27 May	1	4	4				
28 May			1	3			
29 May			3		1	1	
30 May	1	3	2		1		
31 May	1	3					
01 Jun						1	
03 Jun	1	3			1		
04 Jun					1		
05 Jun			1				1
06 Jun						1	
07 Jun	2	5					
09 Jun			1				
11 Jun			1	1		1	
12 Jun	1	3	2	1			
14 Jun				1			
15 Jun			1				
16 Jun	1	3	1				
17 Jun			1				
19 Jun						1	
20 Jun	1	2					
21 Jun	2	4					
23 Jun			2				
26 Jun				1			
Totals	39	131	70	20	10	9	1

Appendix Table 6. Detections of PIT-tagged smolts by date at three Snake River dams and three Columbia River dams for wild chinook salmon from Elk Creek, 1999.

Tagging site: Elk Creek Release date: 31 Jul-01 Aug 1998
Release site: Elk Creek Number released: 700
Release River Kilometer(s) above Lower Granite Dam: 634 - 638

Detection date	Lower Granite		First Detections				
	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
01 Apr	1	6					
13 Apr	1	8					
17 Apr			1				
18 Apr			1	1			
19 Apr			1				
21 Apr	2	7					
22 Apr	4	13	1	1	1		
23 Apr	1	3	3				
24 Apr	2	7					
25 Apr			1				
26 Apr	3	11	2				
27 Apr	3	11	3				
28 Apr			2				
29 Apr			3	1			
30 Apr			1				
01 May	1	3	1	4			
02 May	1	3		3			
03 May	4	13		2			
04 May			1		1		
05 May			4		1		
06 May	1	3					
07 May			1				
08 May	1	4					
09 May	2	11	1				
10 May				2			
11 May			1				
13 May				1	1		
14 May	1	6	1				
15 May			1	1			
17 May	1	5	1				
18 May	1	5	2	2			
19 May	1	5	2	1			
20 May			1				
21 May			2		1		
22 May	1	5					
23 May			2				

Appendix Table 6. Continued.

Detection date	Lower Granite		First Detections				
	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
24 May			2				
25 May	3	13	1				
27 May	1	4	2				
28 May			4	1			
29 May			3	1			
30 May			1		1		
31 May	1	3	1				
05 Jun				2		1	
06 Jun	1	3	2	1	1		
07 Jun			1				
10 Jun				1			
11 Jun			1				
12 Jun			2				
14 Jun					1		
19 Jun	2	4					
30 Jun			1				
03 Jul	1	2					
04 Jul	1	2					
08 Jul	1	1					
Totals	44	161	61	25	8	1	0

Appendix Table 7. Detections of PIT-tagged smolts by date at three Snake River dams and three Columbia River dams for wild chinook salmon from Sulphur Creek, 1999.

Tagging site: Sulphur Creek Release date: 04 Aug 1998
Release site: Sulphur Creek Number released: 443
Release River Kilometer(s) above Lower Granite Dam: 604 - 606

Detection date	Lower Granite		First Detections				
	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
22 Apr	1	3					
23 Apr			1	1			
24 Apr	2	7					
25 Apr	1	4					
26 Apr	1	4					
27 Apr	1	4	2				
29 Apr			1				
30 Apr			1				
01 May			1				
02 May				1			
03 May			1				
04 May					1		
06 May			1				
07 May			1	1			
08 May	1	4					
09 May			1				
10 May			1				
11 May			1				
12 May					1		
14 May	1	6		1			
17 May				1			
19 May	1	5					
20 May			3				
21 May	1	5					
22 May	1	5			1		
23 May	1	5					
24 May			2				
25 May	1	4		2			
26 May	2	8	1		1		
27 May	1	4	1	2			
28 May			1	1	1		
29 May	1	4	1	1			
30 May			3				
06 Jun							1
15 Jun			1				
Totals	17	71	25	11	5	0	1

Appendix Table 8. Detections of PIT-tagged smolts by date at three Snake River dams and three Columbia River dams for wild chinook salmon from Marsh Creek, 1999.

Tagging site: Marsh Creek
Release site: Marsh Creek
Release River Kilometer(s) above Lower Granite Dam: 630-633
Release date: 07-08 Aug 1998
Number released: 770

Detection date	Lower Granite		First Detections				
	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
11 Apr	1	8					
14 Apr			1				
15 Apr			1				
16 Apr	1	8					
18 Apr				2			
20 Apr	1	4	1				
21 Apr	2	7	2				
22 Apr	1	3	1				
23 Apr	2	7					
24 Apr	3	11					
25 Apr	3	11		1			
26 Apr	3	11	1				
27 Apr	2	7	6	1			
28 Apr	6	19	2				
29 Apr	3	9	4	1			
30 Apr			4				
01 May	4	12	3		1		
02 May	3	9	3	1			
03 May	3	13	1	1	1		
04 May	1	3	5	1			
05 May	3	10	1				
06 May			3	1	1		
07 May			2	1			
08 May			2	2			
09 May	1	4					
10 May			2	1			
11 May	2	7	4	1			
12 May				1			
13 May			1	1			
14 May	1	6	1		1		
15 May	2	12	1				
16 May				2			
17 May	1	5					
18 May			2	2	1		
20 May	1	5	1	1		1	
21 May				1			
22 May				1			

Appendix Table 8. Continued.

Detection date	Lower Granite		First Detections				
	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
23 May	1	5	1				
24 May			2		1		
25 May	1	4	1	1			
26 May	1	4	1				
27 May	1	4	1				
28 May				1			
30 May			1	1			
01 Jun	1	3	2				
02 Jun							1
03 Jun			1			3	
04 Jun			2				
05 Jun				2			
06 Jun	1	3					
13 Jun	1	4					
22 Jun				1			
23 Jun			1				
Totals	58	218	68	29	6	4	1

Appendix Table 9. Detections of PIT-tagged smolts by date at three Snake River dams and three Columbia River dams for wild chinook salmon from Cape Horn Creek, 1999.

Tagging site: Cape Horn Creek
Release site: Cape Horn Creek
Release River Kilometer(s) above Lower Granite Dam: 630-632
Release date: 08 Aug 1998
Number released: 270

Detection date	Lower Granite		First Detections				
	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
25 Apr	1	4					
29 Apr	1	3	2				
30 Apr			1	1			
02 May	1	3					
03 May	1	3					
05 May			2				
06 May	1	3	1	1			
07 May				1			
08 May			1				
09 May	1	4					
10 May	1	4		1			
13 May			2				
16 May					1		
17 May			2				
19 May			1				
20 May			2				
21 May			1				
22 May	1	5					
23 May			1		1		
24 May	1	5	1				
25 May	2	9	1				
27 May			1	1			
28 May	2	7	2	1			
29 May	1	4	2	1			
30 May			2				
03 Jun			1				
10 Jun						1	
12 Jun	1	3					
13 Jun			1				
14 Jun			1				
17 Jun				1			
21 Jun				1			
Totals	15	57	28	9	2	1	

Appendix Table 10. Detections of PIT-tagged smolts by date at three Snake River dams and three Columbia River dams for wild chinook salmon from Valley Creek, 1999.

Tagging site: Valley Creek Release date: 10-12 Aug 1998
Release site: Valley Creek Number released: 1,001
Release River Kilometer(s) above Lower Granite Dam: 743-757

Detection date	Lower Granite		First Detections				
	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
15 Apr				1			
17 Apr			2				
18 Apr			1				
19 Apr	1	5					
20 Apr				1			
21 Apr	2	7	2	1			
22 Apr			2				
23 Apr	1	3	2				
24 Apr	1	4	2	1			
25 Apr	1	4					
26 Apr			1				
27 Apr	3	11	7	1			
28 Apr	1	3		1			
29 Apr	4	12	5	2			
30 Apr	2	6	1				
01 May	2	6	1				
02 May			8	3			
03 May	3	10	2				
04 May			2				
05 May	1	3					
06 May	1	3	2				
07 May	1	4	2	1			
08 May				1	1		
10 May			3				
11 May			1				
12 May	1	5		2			
13 May	1	6					
14 May				1			
15 May	1	6	1	1			
17 May			2		1		
18 May	1	5		1			
19 May	1	5					
20 May			1	1			
21 May					2		
22 May	3	16	3				
23 May	1	5	2	2			

Appendix Table 10. Continued.

Detection date	Lower Granite		First Detections				
	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
24 May			3				
25 May	1	4	1	1			
26 May				1			
27 May	2	8	1	1			
28 May			1	4	1		
29 May	1	4	3				
30 May			1	1			
31 May			3	1			1
01 Jun			2				
02 Jun			1				
03 Jun			1				
04 Jun			2				
06 Jun	2	5					
07 Jun	1	3					
08 Jun	1	3					
09 Jun				1			
10 Jun			1	2			
12 Jun	1	3		2			
13 Jun			1				
17 Jun			1				
18 Jun	2	5					
19 Jun	1	2					
21 Jun	2	4	1				
22 Jun				1		1	
23 Jun			1	1			
25 Jun							1
26 Jun	1	2					
28 Jun	1	2					
01 Jul	1	2	1				
10 Jul				1			
Totals	50	173	80	38	5	1	2

Appendix Table 11. Detections of PIT-tagged smolts by date at three Snake River dams and three Columbia River dams for wild chinook salmon from Loon Creek, 1999.

Tagging site: Loon Creek Release date: 14-15 Aug 1998
Release site: Loon Creek Number released: 1,029
Release River Kilometer(s) above Lower Granite Dam: 555-557

Detection date	Lower Granite		First Detections				
	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
14 Apr			1				
22 Apr	1	3					
24 Apr	1	4					
27 Apr	4	14					
28 Apr			2	2			
29 Apr	2	6	4				
30 Apr	2	6	2				
01 May	5	14	3				
02 May	2	6	1	1			
03 May	3	10	4				
04 May	2	7	2				
05 May	3	10	2				
06 May	1	3	3				
07 May	1	4	3				
08 May	2	7	3	2			
09 May	1	4	2	4	1		
10 May			5	1			
11 May	1	4	2				
12 May	2	9	2	2	1		
13 May	1	6	4				
14 May			1				
15 May	2	12	2		2		
16 May	1	5	2	1			
17 May			4			1	1
18 May	3	16	6	1			
19 May	1	5	4	2			
20 May			4	3		1	
21 May	2	10	3		1		
22 May	5	26	3				
23 May	2	10	6	1			
24 May	2	14	5	1			
25 May	5	17	5	2	1		1
26 May	4	17	3	1			
27 May	5	19	2	3			1
28 May			9	4	1		
29 May	2	7	10	5			

Appendix Table 11. Continued.

Detection date	Lower Granite		First Detections				
	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
30 May			6	3			
31 May	1	3	4	1		2	
01 Jun			2	4		1	
02 Jun			1	1			1
03 Jun			2	1	1	1	1
04 Jun						1	1
05 Jun			1	1		2	
06 Jun			2	2	1		
07 Jun	1	3	3	2		1	
12 Jun			2				
16 Jun	1	3					
19 Jun				1			
Totals	71	283	137	52	9	10	6

Appendix Table 12. Detections of PIT-tagged smolts by date at three Snake River dams and three Columbia River dams for wild chinook salmon from Herd Creek, 1999.

Tagging site: Herd Creek Release date: 17-18 Aug 1998
Release site: Herd Creek Number released: 959
Release River Kilometer(s) above Lower Granite Dam: 699-701

Detection date	Lower Granite		First Detections				
	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
30 Mar	1	5					
11 Apr	1	8					
17 Apr			1				
18 Apr	1	7					
20 Apr	1	4	2				
21 Apr	1	3	2				
22 Apr	1	7	3				
23 Apr	4	10	1				
24 Apr				1			
25 Apr	4	19	2				
26 Apr	2	4	6		1		
27 Apr	5	18	2				
28 Apr	2	6	8				
29 Apr	7	22	6	1			
30 Apr	2	6	5				
01 May	3	9	6	1			
02 May	4	12	2		2		
03 May	1	3	2	1			
04 May	3	10	4				
05 May	4	13	1				
06 May	1	3	4				
07 May	1	4	3	2			
08 May	3	11	5	1	1		
09 May	1	4	1	1			
10 May	1	4	2	1	2		
11 May			2	2			
12 May	1	5		1			
13 May			2		1		
14 May	2	11	1				
15 May				1			
16 May			1				
17 May						1	
18 May			2				
19 May				1		1	1
20 May	1	5	1	1			
21 May						1	
22 May			2				
23 May			1				
25 May			2				
27 May			1				
01 Jun							1
Totals	58	211	83	15	7	3	2

Appendix Table 13. Detections of PIT-tagged smolts by date at three Snake River dams and three Columbia River dams for wild chinook salmon from Big Creek (upper), 1999.

Tagging site: Big Creek (upper) Release date: 20-21 Aug 1998
Release site: Big Creek (upper) Number released: 960
Release River Kilometer(s) above Lower Granite Dam: 530-533

Detection date	Lower Granite		First Detections				
	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
25 Apr	1	4					
26 Apr	2	7					
27 Apr	1	4					
28 Apr	1	3					
29 Apr	1	3	3				
30 Apr			1				
01 May	2	6		1			
02 May	1	3	2				
03 May	1	3					
04 May	1	3	1				
06 May	1	3					
09 May	2	8	3				
10 May	2	8	1				
11 May	1	4	2			2	
12 May	2	9		1			
14 May	2	11	2				
15 May			1				
16 May			1				
17 May	1	5	3				
18 May				1			
19 May			2		1	1	
20 May	1	5					
22 May	1	5					
23 May			3				
24 May	1	5					
25 May	1	4	5	1			1
26 May	2	8	3		1		
27 May	2	8	2	1			
28 May	1	4	1				
29 May			1	1			
30 May			5	1			
31 May			2				
02 Jun	2	6	3			1	
03 Jun	2	6	1	1			
04 Jun			3				
05 Jun			2				

Appendix Table 13. Continued.

Detection date	Lower Granite		First Detections				
	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
06 Jun	2	5	1			2	
07 Jun			3				
08 Jun			1				
10 Jun			1				
11 Jun				1			
15 Jun	1	2					
16 Jun				1			
17 Jun	1	3					
18 Jun	1	3				1	
19 Jun	1	2					
20 Jun				1			
21 Jun			2	2			
26 Jun			1				
02 Jul				1			
Totals	42	155	63	14	2	7	1

Appendix Table 14. Detections of PIT-tagged smolts by date at three Snake River dams and three Columbia River dams for wild chinook salmon from South Fork Salmon River, 1999.

Tagging site: South Fork Salmon River Release date: 23-24 Aug 1998
Release site: South Fork Salmon River Number released: 1,004
Release River Kilometer(s) above Lower Granite Dam: 467- 472

Detection date	Lower Granite		First Detections				
	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
27 Mar	1	8					
30 Mar	1	5					
31 Mar	1	6					
18 Apr				1			
21 Apr	2	7	1				
22 Apr	2	7					
23 Apr	1	3	2				
24 Apr	3	11					
25 Apr	2	7					
26 Apr	1	4	2				
27 Apr			2				
28 Apr	1	3	5	1			
29 Apr	1	3	2	1			
30 Apr	1	3	3	1			
01 May				1			
02 May			1	1			
03 May	1	3		1			
04 May	2	7	1				
06 May			1		1		
07 May			1	1	1		
08 May	2	7					
09 May				1			
10 May			2				
11 May			1				
13 May	1	6		1			
14 May			1				
15 May					1	1	
19 May			2				
20 May			1	1			
22 May			1				
24 May	1	5	1				
25 May	2	9	3				
26 May	1	4					
27 May	3	11					
28 May			2				
29 May	1	4	1	1			
30 May	1	3	1	1			
31 May			1				

Appendix Table 14. Continued.

Detection date	Lower Granite		First Detections				
	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
01 Jun	1	3	1	1	1		
02 Jun			1	1			
03 Jun				1			1
06 Jun				1			
07 Jun	1	3					
08 Jun	2	5					
09 Jun							
10 Jun				1			
11 Jun	2	6					
12 Jun			1	2			
21 Jun				1			
24 Jun			1				
25 Jun			1				
28 Jun			1				
Totals	38	142	44	21	4	1	1

Appendix Table 15. Detections of PIT-tagged smolts by date at three Snake River dams and three Columbia River dams for wild chinook salmon from Big Creek (lower), 1999.

Tagging site: Big Creek (lower) Release date: 31 Aug 1998
Release site: Big Creek (lower) Number released: 467
Release River Kilometer(s) above Lower Granite Dam: 487-489

Detection date	Lower Granite		First Detections				
	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
04 Apr	1	5					
10 Apr	1	7					
18 Apr	1	7					
19 Apr	1	5					
20 Apr	1	4					
21 Apr	1	3	1				
22 Apr	1	3	2				
23 Apr	2	7	3				
24 Apr	5	18	2				
25 Apr	3	11					
26 Apr	4	14	1				
27 Apr	6	21	8				
28 Apr	5	16	3	1			
29 Apr	4	12	6	2			
30 Apr	2	6	2	2			
01 May	3	9	1	1			
02 May	1	3	4	3			
03 May	2	6	3	2			
04 May	1	3	5	2	1		
05 May	1	3	7	2			
06 May			3				
07 May	3	11	2			1	
08 May			4	1			
09 May			1				
10 May			3	1			
11 May			2	1	1		
13 May	1	6	2				
14 May			1				
17 May			4				
18 May			1				
20 May	2	10		1	1		
21 May			1				
22 May			1				
23 May	2	10	2	1			
24 May	2	10	1	1			
26 May			1		1		
27 May				1			

Appendix Table 15. Continued.

Detection date	Lower Granite		First Detections				
	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
28 May	1	4					
29 May			1				
30 May	1	3	1			1	
01 Jun							1
03 Jun						1	
08 Jun			1				
Totals	58	218	80	22	4	3	1

Appendix Table 16. Detections of PIT-tagged smolts by date at three Snake River dams and three Columbia River dams for wild chinook salmon from Rush Creek, 1999.

Tagging site: Rush Creek Release date: 31 Aug 1998
Release site: Rush Creek Number released: 27
Release River Kilometer(s) above Lower Granite Dam: 490

Detection date	Lower Granite		First Detections				
	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
21 Apr			1				
22 Apr			1				
01 May			1				
05 May	1	3					
06 May					1		
09 May			1				
29 May				1			
Totals	1	3	4	1	1	0	0

Appendix Table 17. A summary of the tagging dates, start tagging times and temperatures (°C), release dates, times, and temperatures, method of capture, distance (in kilometers) from the stream's mouth to the release point, number released, number detected (unadjusted), and percent detected for each tag group at six downstream dams during 1999.

Stream	Tag group	Tagging date	Tagging time	Release date	Release time	Tagging temperature	Release temperature	Capture method	Release River Km	Number released	Number detected	Percent detected
Bear Valley Creek	SA98210.BV1	29 July	08:00	30 July	06:40	11.0	11.0	Shock	12	160	24	15.0
	SA98210.BV2	29 July	10:38	29 July	13:30	12.0	14.0	Shock	13	276	65	23.6
	SA98211.BV1	30 July	07:45	30 July	12:00	11.0	13.5	Shock	15	384	60	15.6
Elk Creek	SA98211.EC1	30 July	11:25	31 July	06:30	13.0	11.5	Shock	1	97	22	22.7
	SA98212.EC1	31 July	06:32	31 July	10:00	11.5	12.0	Shock	2	87	14	16.1
	SA98212.EC2	31 July	09:10	01 Aug	07:15	12.0	11.0	Shock	3	258	51	19.8
	SA98212.EC3	31 July	13:00	01 Aug	08:00	14.5	11.0	Shock	3	104	16	15.4
	SA98213.EC1	01 Aug	09:15	01 Aug	10:50	11.0	11.0	Shock	4	154	36	23.4
Sulphur Creek	SA98215.SU1	03 Aug	09:30	04 Aug	06:45	8.0	8.0	Shock	5	205	30	14.6
	SA98216.SU1	04 Aug	08:07	04 Aug	09:30	8.0	8.0	Shock	6	41	8	19.5
	SA98216.SU2	04 Aug	10:30	04 Aug	12:45	9.0	10.5	Shock	7	197	21	10.7
Marsh Creek	SA98219.MC1	07 Aug	07:09	08 Aug	06:45	7.5	7.0	Shock	11	132	27	20.5
	SA98219.MC2	07 Aug	09:08	07 Aug	13:00	8.0	14.0	Shock	13	414	87	21.0
	SA98220.MC1	08 Aug	08:00	08 Aug	09:30	7.0	8.0	Shock	13	65	13	20.0
	SA98220.MC2	08 Aug	10:30	08 Aug	12:00	8.5	12.0	Shock	14	159	39	24.5
Cape Horn Creek	SA98220.CH1	08 Aug	08:51	08 Aug	10:50	7.0	4.5	Shock	1	149	22	14.8
	SA98220.CH2	08 Aug	11:17	08 Aug	12:45	10.0	8.0	Shock	2	121	33	27.3

Appendix Table 17. Continued.

Stream	Tag group	Tagging date	Tagging time	Release date	Release time	Tagging temperature	Release temperature	Capture method	Release River Km	Number released	Number detected	Percent detected
Valley Creek	SA98222.VC1	10 Aug	08:10	11 Aug	08:00	10.0	11.0	Shock	4	66	11	16.7
	SA98222.VC2	10 Aug	09:04	11 Aug	08:00	10.0	11.0	Seine	4	82	19	23.2
	SA98222.VC3	10 Aug	10:26	10 Aug	13:10	11.0	16.0	Shock	6	74	10	13.5
	SA98223.VC1	11 Aug	08:49	11 Aug	11:00	11.0	14.0	Shock	8	145	30	20.7
	SA98223.VC2	11 Aug	10:37	11 Aug	12:00	13.5	15.5	Shock	9	48	13	27.1
	SA98223.VC3	11 Aug	12:16	11 Aug	13:00	15.5	14.0	Shock	10	165	27	16.4
	SA98224.VC1	12 Aug	08:30	12 Aug	10:00	8.0	9.5	Shock	17	141	15	10.6
	SA98224.VC2	12 Aug	09:56	12 Aug	12:00	9.5	13.0	Shock	18	280	51	18.2
Loon Creek*	SA98226.LN1	14 Aug	08:38	15 Aug	08:00	9.0	9.0	Shock	33	108	20	18.5
	SA98226.LN2	14 Aug	09:58	14 Aug	12:45	10.5	13.0	Shock	34	241	62	25.7
	SA98226.LN3	14 Aug	12:10	14 Aug	13:30	12.0	13.0	Shock	35	388	108	27.8
	SA98227.LN1	15 Aug	09:40	15 Aug	12:45	9.5	11.0	Shock	35	292	96	32.9
Herd Creek	SA98229.HC1	17 Aug	09:28	18 Aug	13:30	8.5	12.0	Shock	2	134	20	14.9
	SA98229.HC2	17 Aug	10:42	17 Aug	13:00	10.0	13.0	Shock	2	296	46	15.5
	SA98230.HC1	18 Aug	09:29	18 Aug	13:30	8.0	12.0	Shock	4	529	102	19.3
Big Creek (upper)	SA98232.BC1	20 Aug	08:44	21 Aug	07:15	7.0	7.0	Shock	52	118	26	22.0
	SA98232.BC2	20 Aug	09:32	20 Aug	13:15	8.5	12.5	Shock	53	368	64	17.4
	SA98233.BC1	21 Aug	09:11	21 Aug	11:00	6.5	8.5	Shock	53	86	14	16.3
	SA98233.BC2	21 Aug	09:58	21 Aug	13:00	8.0	9.5	Shock	55	388	25	6.4

Appendix Table 17. Continued.

Stream	Tag group	Tagging date	Tagging time	Release date	Release time	Tagging temperature	Release temperature	Capture method	Release River Km	Number released	Number detected	Percent detected
S. F. Salmon River	SA98235.SF1	23 Aug	08:51	24 Aug	07:30	9.0	9.0	Shock	116	121	12	9.9
	SA98235.SF2	23 Aug	10:17	23 Aug	12:30	9.0	11.0	Shock	117	225	24	10.7
	SA98235.SF3	23 Aug	12:26	23 Aug	14:00	10.5	12.5	Shock	117	228	25	11.0
	SA98236.SF1	24 Aug	09:04	24 Aug	12:15	8.5	9.5	Shock	120	430	48	11.2
Secesh River	SA98238.SE1	26 Aug	08:52	27 Aug	07:35	8.5	7.5	Shock	25	92	8	8.7
	SA98238.SE2	26 Aug	09:51	26 Aug	13:45	8.5	12.0	Shock	26	378	59	15.6
	SA98239.SE1	27 Aug	08:34	27 Aug	12:00	8.0	9.5	Shock	27	466	51	10.9
Lake Creek	SA98240.LC1	28 Aug	09:02	28 Aug	13:00	6.0	10.0	Shock	1	545	83	15.2
Big Creek (lower)	SA98242.BC1	30 Aug	09:56	31 Aug	07:30	11.0	11.0	Shock	9	112	44	39.3
	SA98242.BC2	30 Aug	11:50	31 Aug	08:00	12.0	11.0	Shock	10	134	42	31.3
	SA98243.BC1	31 Aug	09:02	31 Aug	11:45	10.0	12.0	Shock	11	106	40	37.7
	SA98243.BC2	31 Aug	11:20	31 Aug	12:15	11.5	13.0	Shock	11	35	8	22.9
	SA98243.BC3	31 Aug	12:09	31 Aug	13:00	13.0	14.0	Shock	11	80	34	42.5
Rush Creek	SA98243.RC1	31 Aug	11:30	31 Aug	12:15	12.0	10.0	Shock	1	27	7	25.9

* Detection numbers from this stream include one first-time detection at the PIT-trawl in the mouth of the Columbia River.

Appendix Table 18. Daily and expanded detections of PIT-tagged wild spring/summer chinook salmon smolts from Idaho at Lower Granite Dam during 1999, with associated river flows (kcfs), spill (kcfs), and water temperatures (°C) at the dam.

Date	Average flow (kcfs)	Average spill (kcfs)	Scroll-case water temperature	Numbers detected	Expanded numbers detected
27 Mar	127.9	41.1	7.7	1	8
29 Mar	112.9	1.6	7.1	1	6
30 Mar	99.4	0.7	7.0	2	9
31 Mar	95.5	0.0	7.0	1	6
01 Apr	85.2	0.0	6.9	1	6
03 Apr	89.2	27.5	7.3	1	8
04 Apr	83.3	26.5	7.4	1	5
05 Apr	79.6	30.6	7.9	1	2
06 Apr	76.9	29.8	7.8	1	6
07 Apr	75.7	31.8	8.1	0	0
08 Apr	74.5	32.4	8.0	1	6
09 Apr	75.0	31.7	8.1	1	5
10 Apr	76.4	33.2	8.3	1	7
11 Apr	72.8	33.6	8.7	2	15
12 Apr	75.3	34.3	8.2	0	0
13 Apr	79.6	35.2	8.2	1	8
14 Apr	81.7	35.2	8.6	0	0
15 Apr	80.2	35.3	9.2	0	0
16 Apr	83.2	35.1	9.4	1	8
17 Apr	85.2	35.4	9.6	0	0
18 Apr	91.0	35.2	9.7	3	20
19 Apr	98.3	33.8	9.9	2	10
20 Apr	118.7	33.4	10.0	7	27
21 Apr	126.3	32.6	9.8	13	44
22 Apr	122.4	32.5	9.5	18	59
23 Apr	118.7	33.3	9.3	21	71
24 Apr	103.9	34.4	9.8	22	78
25 Apr	110.7	51.3	10.0	22	82
26 Apr	113.7	45.1	10.3	19	69
27 Apr	123.2	48.9	10.5	29	102
28 Apr	122.0	47.4	10.2	17	54
29 Apr	108.9	34.4	10.0	26	80
30 Apr	100.2	33.5	9.7	11	33

Appendix Table 18. Continued.

Date	Average flow (kcfs)	Average spill (kcfs)	Scroll-case water temperature	Numbers detected	Expanded numbers detected
01 May	98.7	34.5	9.2	21	61
02 May	102.2	34.4	9.7	17	53
03 May	103.8	34.5	9.7	22	71
04 May	109.1	34.2	9.8	11	37
05 May	100.7	34.2	10.0	13	43
06 May	98.2	34.6	10.1	7	22
07 May	92.0	34.5	10.3	7	25
08 May	95.7	34.5	10.6	12	44
09 May	93.4	34.7	10.6	10	38
10 May	95.8	33.5	10.4	4	17
11 May	88.4	33.6	10.0	4	15
12 May	87.0	35.3	10.0	6	28
13 May	86.5	35.3	10.3	4	23
14 May	86.6	35.4	10.7	7	40
15 May	83.1	35.2	10.7	5	29
16 May	81.1	36.1	10.8	1	5
17 May	82.7	35.3	11.0	3	16
18 May	82.3	35.0	11.1	6	31
19 May	88.7	35.2	11.5	4	21
20 May	88.9	35.3	11.8	6	31
21 May	94.4	34.8	11.9	3	15
22 May	113.6	44.3	12.6	13	67
23 May	115.7	35.0	13.2	9	47
24 May	131.4	42.3	12.9	8	38
25 May	154.8	56.2	12.5	17	74
26 May	181.2	78.8	12.4	12	50
27 May	187.5	84.6	11.7	17	64
28 May	161.4	58.8	11.5	4	15
29 May	157.8	57.9	11.5	7	25
30 May	172.1	71.6	11.6	4	14
31 May	172.7	68.7	11.6	3	10
01 Jun	169.2	65.6	11.3	2	7
02 Jun	174.3	70.4	11.5	2	6
03 Jun	161.7	60.3	11.7	3	10
04 Jun	152.5	59.0	11.2	0	0

Appendix Table 18. Continued.

Date	Average flow (kcfs)	Average spill (kcfs)	Scroll-case water temperature	Numbers detected	Expanded numbers detected
05 Jun	151.7	56.4	10.9	1	3
06 Jun	146.5	51.0	11.1	6	15
07 Jun	138.3	44.5	11.5	7	18
08 Jun	137.7	59.5	11.4	3	8
11 Jun	108.8	32.0	12.4	2	6
12 Jun	107.6	35.5	13.3	3	8
13 Jun	108.2	33.1	13.9	1	4
15 Jun	131.4	41.2	14.2	1	2
16 Jun	147.7	51.9	14.3	2	5
17 Jun	156.0	56.0	14.7	1	3
18 Jun	157.4	59.3	14.1	3	8
19 Jun	165.8	63.7	14.0	4	9
20 Jun	162.6	61.0	14.1	4	9
21 Jun	150.6	48.9	14.1	3	6
26 Jun	120.0	44.3	14.8	1	2
28 Jun	98.6	21.9	14.9	1	2
01 Jul	82.5	7.0	15.8	1	2
03 Jul	68.2	0.0	16.2	1	2
04 Jul	64.7	0.0	16.1	1	2
08 Jul	54.6	0.0	16.4	1	1

Appendix Table 19. Daily first-time detections of PIT-tagged wild spring/summer chinook salmon smolts from Idaho at Little Goose Dam during 1999, with associated river flows (kcfs), spill (kcfs), and water temperatures (°C) at the dam.

Date	Average flow (kcfs)	Average spill (kcfs)	Scroll-case water temperature	Numbers detected
11 Apr	68.7	24.5	8.1	1
12 Apr	73.1	28.0	8.2	1
13 Apr	77.3	25.1	8.4	1
14 Apr	78.6	24.8	8.6	6
15 Apr	76.6	26.1	8.7	2
17 Apr	81.6	24.4	9.0	5
18 Apr	85.3	24.5	9.4	4
19 Apr	95.7	23.7	9.6	2
20 Apr	113.6	23.6	9.8	5
21 Apr	123.0	32.8	10.0	15
22 Apr	117.9	19.1	10.2	18
23 Apr	112.8	18.3	10.2	15
24 Apr	101.7	17.7	10.0	5
25 Apr	104.3	14.6	9.8	6
26 Apr	109.6	14.7	9.9	18
27 Apr	117.5	15.2	10.2	44
28 Apr	119.0	27.6	10.3	31
29 Apr	99.2	17.2	10.4	49
30 Apr	97.2	20.5	10.4	28
01 May	95.4	19.3	10.4	22
02 May	101.2	17.5	10.0	22
03 May	99.5	17.2	9.4	17
04 May	106.5	18.5	9.4	24
05 May	94.5	20.3	9.7	19
06 May	94.5	21.1	10.0	20
07 May	88.3	20.8	10.0	19
08 May	92.9	19.8	10.0	17
09 May	89.3	20.0	10.1	12
10 May	93.0	20.7	10.4	20
11 May	84.7	21.1	10.8	17
12 May	82.4	22.3	10.8	3
13 May	81.5	22.1	10.5	12
14 May	83.0	22.4	10.2	9
15 May	80.8	22.9	10.2	6
16 May	78.2	24.8	10.6	7
17 May	78.8	22.5	10.9	17

Appendix Table 19. Continued.

Date	Average flow (kcfs)	Average spill (kcfs)	Scroll-case water temperature	Numbers detected
18 May	78.2	22.7	11.1	16
19 May	84.1	22.1	11.1	12
20 May	86.4	22.0	11.3	16
21 May	89.8	21.9	11.4	7
22 May	107.5	22.2	11.8	13
23 May	111.5	22.7	12.3	22
24 May	124.9	26.5	12.7	19
25 May	144.5	37.4	13.1	22
26 May	172.8	73.6	13.0	11
27 May	178.5	63.3	12.7	16
28 May	153.9	39.5	12.4	22
29 May	149.8	37.5	12.2	25
30 May	164.1	49.9	12.0	25
31 May	162.8	47.1	11.9	14
01 Jun	160.4	43.7	----	9
02 Jun	165.5	46.3	11.8	7
03 Jun	155.5	42.0	11.7	7
04 Jun	148.1	39.3	12.1	7
05 Jun	143.1	37.1	12.1	5
06 Jun	139.1	29.5	11.6	5
07 Jun	131.5	21.9	11.2	7
08 Jun	132.5	24.7	11.6	2
09 Jun	125.1	33.5	11.7	1
10 Jun	113.9	20.2	11.8	2
11 Jun	105.8	19.7	12.4	2
12 Jun	106.0	20.2	12.5	7
13 Jun	104.7	21.0	12.7	2
14 Jun	112.6	22.8	13.3	1
15 Jun	125.3	24.3	14.0	2
16 Jun	141.3	29.3	14.6	2
17 Jun	146.7	41.4	14.7	2
21 Jun	146.7	29.6	14.2	3
23 Jun	131.8	18.9	14.5	4
24 Jun	116.1	3.3	14.8	1
25 Jun	114.6	0.3	14.8	1
26 Jun	116.1	4.5	14.7	1
28 Jun	96.7	0.0	15.0	1
30 Jun	85.7	0.0	15.3	1
01 Jul	81.6	0.0	15.5	2

Appendix Table 20. Daily first-time detections of PIT-tagged wild spring/summer chinook salmon smolts from Idaho at Lower Monumental Dam during 1999, with associated river flows (kcfs), spill (kcfs), and water temperatures (°C) at the dam.

Date	Average flow (kcfs)	Average spill (kcfs)	Scroll-case water temperature	Numbers detected
13 Apr	82.0	19.1	8.4	1
15 Apr	81.6	19.3	8.7	1
17 Apr	85.7	19.1	9.0	1
18 Apr	88.5	17.6	9.2	5
20 Apr	121.2	20.9	9.7	2
21 Apr	130.1	19.7	9.8	1
22 Apr	124.7	13.1	10.1	1
23 Apr	119.3	14.0	10.3	1
24 Apr	107.3	14.1	10.5	6
25 Apr	107.9	13.9	10.5	4
26 Apr	114.8	12.3	10.2	1
27 Apr	124.3	13.5	10.1	3
28 Apr	126.7	16.7	10.2	6
29 Apr	102.2	14.8	10.3	11
30 Apr	102.1	16.6	10.6	8
01 May	97.4	17.6	10.8	10
02 May	106.0	16.9	10.6	16
03 May	102.3	15.6	10.4	8
04 May	113.7	15.7	9.9	3
05 May	98.1	15.3	9.5	2
06 May	102.1	19.4	9.8	4
07 May	88.8	18.3	10.1	8
08 May	97.9	18.1	10.2	7
09 May	92.0	17.6	10.2	6
10 May	95.9	19.0	10.3	7
11 May	89.8	17.6	10.4	5
12 May	86.2	18.6	10.8	8
13 May	83.7	17.9	11.1	4
14 May	85.9	18.9	11.0	2
15 May	83.2	18.0	10.8	3
16 May	80.4	20.5	10.6	3
17 May	81.6	19.1	10.7	1
18 May	78.6	19.5	11.0	8
19 May	88.2	18.6	11.3	4

Appendix Table 20. Continued.

Date	Average flow (kcfs)	Average spill (kcfs)	Scroll-case water temperature	Numbers detected
20 May	88.9	19.1	11.6	8
21 May	91.3	17.6	11.5	2
22 May	113.3	19.8	11.7	2
23 May	115.5	19.9	12.0	5
24 May	131.0	19.2	12.5	2
25 May	150.9	34.4	13.0	9
26 May	184.5	62.4	13.4	2
27 May	186.1	66.1	13.2	9
28 May	150.7	35.8	13.0	16
29 May	156.9	35.1	12.7	12
30 May	172.5	49.8	12.4	8
31 May	172.7	50.8	12.1	2
01 Jun	168.5	45.3	12.0	5
02 Jun	176.6	53.2	11.9	2
03 Jun	164.4	43.2	11.9	4
05 Jun	149.2	37.5	12.3	6
06 Jun	145.1	28.6	12.2	4
07 Jun	138.1	18.6	11.8	2
09 Jun	129.7	24.9	11.5	1
10 Jun	120.8	15.2	11.9	4
11 Jun	110.2	14.9	12.1	2
12 Jun	109.4	15.3	12.4	5
14 Jun	119.1	16.8	13.1	1
15 Jun	132.5	17.6	13.5	1
16 Jun	147.4	30.9	14.2	1
17 Jun	153.5	31.5	14.9	2
19 Jun	165.4	46.1	15.0	1
20 Jun	166.5	43.5	14.9	1
21 Jun	151.4	29.1	14.5	4
22 Jun	143.3	21.7	14.5	2
23 Jun	135.9	14.2	14.6	1
26 Jun	122.6	3.8	14.9	1
02 Jul	83.7	0.0	15.6	1
04 Jul	69.7	0.0	15.7	1
10 Jul	57.3	0.0	17.0	1

Appendix Table 21. Daily first-time detections of PIT-tagged wild spring/summer chinook salmon smolts from Idaho at McNary Dam during 1999, with associated river flows (kcfs), spill (kcfs), and water temperatures (°C) at the dam.

Date	Average flow (kcfs)	Average spill (kcfs)	Scroll-case water temperature	Numbers detected
17 Apr	182.1	51.1	8.7	1
22 Apr	274.3	116.0	9.6	1
24 Apr	286.7	123.2	10.0	1
26 Apr	284.3	118.7	10.2	1
01 May	282.5	129.1	10.3	1
02 May	298.9	140.9	10.3	3
03 May	304.6	138.9	10.2	1
04 May	298.9	134.8	10.0	5
05 May	294.7	135.3	10.2	1
06 May	286.2	122.6	10.3	3
07 May	270.2	104.0	10.3	1
08 May	263.1	110.8	10.3	2
09 May	254.4	108.2	10.3	1
10 May	283.5	128.7	10.4	2
11 May	245.6	112.2	10.5	1
12 May	244.2	115.2	10.7	2
13 May	239.2	106.7	10.7	2
14 May	262.4	114.3	11.0	2
15 May	261.1	109.9	11.0	3
16 May	248.3	104.5	11.2	4
17 May	264.4	114.9	11.5	1
18 May	251.6	108.7	11.7	1
19 May	262.4	110.5	11.8	1
20 May	270.5	123.4	12.1	1
21 May	274.0	121.9	12.2	4
22 May	249.0	108.6	12.4	1
23 May	252.4	111.0	12.9	2
24 May	237.8	96.7	13.2	1
25 May	302.3	134.7	13.6	2
26 May	310.2	144.5	14.0	3
28 May	352.7	183.1	14.2	3
29 May	333.7	167.2	14.2	1
30 May	328.6	175.0	14.2	2
01 Jun	336.4	169.0	13.6	1
03 Jun	359.3	191.0	12.8	2
04 Jun	351.2	181.0	12.8	1
06 Jun	349.8	179.9	13.0	2
14 Jun	299.7	136.5	14.5	1

Appendix Table 22. Monthly environmental data collected from Marsh Creek (RKm 179.5 from the mouth of the Middle Fork Salmon River) from August 1998 through July 1999.

	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
						Temperature (°C)						
Minimum	5.7	4.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	3.8
Maximum	15.6	15.7	10.7	6.1	3.3	3.1	4.6	8.1	9.4	13.2	14.4	15.6
Average	10.7	10.0	4.5	1.8	0.5	0.6	0.7	2.2	3.1	4.2	7.5	10.2
						Dissolved Oxygen (ppm)						
Minimum	7.5	8.0	9.3	9.9	10.2	10.4	10.3	9.8	9.7	0.9	0.9	1.3
Maximum	10.7	11.1	13.6	12.6	12.4	12.2	12.8	13.6	12.6	11.8	2.7	11.1
Average	9.0	9.4	11.1	10.9	11.0	11.2	11.3	11.2	11.1	9.5	1.7	4.7
						Specific Conductance (µS/cm)						
Minimum	55.0	58.0	58.0	45.0	45.0	40.0	43.0	43.0	38.0	18.0	21.0	30.0
Maximum	61.0	63.0	65.0	65.0	61.0	61.0	59.0	59.0	59.0	43.0	31.0	72.0
Average	59.0	60.8	61.5	55.2	54.9	54.5	54.9	54.5	49.9	34.5	26.9	43.3
						Turbidity (ntu)						
Minimum	1.0	----	----	5.0	0.0	2.0	0.0	0.0	1.0	3.0	2.0	0.0
Maximum	21.0	----	----	49.0	49.0	46.0	32.0	50.0	50.0	50.0	41.0	49.0
Average	1.8	----	----	18.4	15.4	5.9	3.5	16.5	13.9	10.4	8.4	8.3
						Depth (feet)						
Minimum	1.0	0.8	0.7	0.8	0.9	0.6	0.7	0.7	0.7	1.4	2.7	1.3
Maximum	1.6	1.3	1.3	1.5	2.8	1.9	2.6	1.4	1.9	3.8	3.8	2.8
Average	1.3	1.1	1.0	1.1	1.7	1.2	1.2	1.0	1.3	2.3	3.3	2.1
						pH						
Minimum	7.3	7.3	7.3	7.3	7.3	7.4	7.5	7.4	7.1	6.8	7.2	7.3
Maximum	8.4	8.7	9.2	9.1	8.9	9.0	9.1	9.4	8.7	7.8	7.7	8.2
Average	7.7	7.7	7.9	7.6	7.6	7.7	7.8	7.9	7.6	7.2	7.4	7.6

Appendix Table 23. Monthly environmental data collected from the Salmon River near Sawtooth Hatchery (RKm 627.9) from August 1998 through July 1999.

	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
						Temperature (°C)						
Minimum	8.1	6.4	0.6	0.5	0.0	0.0	0.0	0.1	0.1	2.0	4.8	7.4
Maximum	15.7	15.6	11.8	7.2	4.2	4.2	5.3	9.8	11.6	13.8	15.3	15.7
Average	12.0	11.3	6.1	3.3	1.1	1.4	1.3	3.7	5.6	7.7	10.1	12.1
						Dissolved Oxygen (ppm)						
Minimum	8.0	3.3	10.2	9.4	4.0	9.9	9.9	9.9	9.5	8.5	9.1	7.3
Maximum	12.2	14.2	14.2	14.2	12.5	13.5	14.2	13.3	14.2	14.2	12.3	11.4
Average	9.7	10.4	11.7	10.8	11.0	11.0	11.3	11.7	11.7	11.2	10.5	9.4
						Specific Conductance (µS/cm)						
Minimum	102.0	125.0	126.0	128.0	160.0	143.0	148.0	150.0	119.0	68.0	57.0	64.0
Maximum	131.0	139.0	136.0	183.0	189.0	176.0	179.0	173.0	166.0	128.0	92.0	128.0
Average	120.0	131.0	130.0	163.0	169.0	166.0	159.0	162.0	148.0	108.0	72.0	90.0
						Turbidity (ntu)						
Minimum	0.7	0.6	0.3	0.0	0.0	0.0	0.0	0.0	0.3	1.5	4.1	0.4
Maximum	49.7	46.8	30.9	15.8	35.4	43.3	42.3	3.1	24.9	49.1	49.4	6.3
Average	5.2	8.3	2.1	0.8	1.1	1.0	1.0	0.7	2.4	10.0	12.2	2.3
						Depth						
Minimum	2.3	2.0	2.1	2.0	2.3	2.1	1.9	2.2	2.2	2.2	2.5	1.7
Maximum	3.0	2.6	2.8	2.9	3.8	3.3	3.4	2.9	3.1	3.5	3.7	2.7
Average	2.6	2.4	2.4	2.5	2.7	2.6	2.6	2.6	2.7	2.9	2.9	2.2
						pH						
Minimum	7.8	7.8	7.8	7.8	7.8	7.9	7.8	7.9	7.8	7.5	7.4	7.6
Maximum	9.1	9.0	9.1	8.6	8.6	8.5	8.7	8.8	8.8	8.9	8.4	8.7
Average	8.3	8.2	8.1	8.1	8.1	8.1	8.1	8.2	8.2	8.0	7.7	8.0

Appendix Table 24. Monthly environmental data collected from Valley Creek (RKm 609.4 from the mouth of the Salmon River) from August 1998 through July 1999.

	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
						Temperature (°C)						
Minimum	8.5	6.1	0.5	0.5	----	----	0.3	0.1	0.2	0.2	3.8	6.3
Maximum	15.7	15.7	13.2	6.6	----	----	1.3	9.2	10.5	14.9	15.5	15.7
Average	12.6	11.4	5.5	2.4	----	----	0.6	2.0	3.9	6.9	9.5	11.4
						Dissolved Oxygen (ppm)						
Minimum	4.7	4.9	4.9	10.3	----	----	11.9	11.3	11.2	9.1	7.0	1.0
Maximum	9.8	10.5	12.6	12.2	----	----	13.4	14.2	14.2	14.2	12.7	8.7
Average	8.2	8.7	10.5	11.4	----	----	12.6	13.2	13.1	11.9	9.7	4.7
						Specific Conductance (µS/cm)						
Minimum	51.0	64.0	64.0	66.0	----	----	72.0	68.0	48.0	35.0	36.0	40.0
Maximum	71.0	72.0	73.0	89.0	----	----	79.0	88.0	86.0	50.0	48.0	52.0
Average	61.4	68.3	68.0	77.9	----	----	75.9	76.9	69.0	44.0	41.7	46.0
						Turbidity (ntu)						
Minimum	0.1	0.2	0.1	0.1	----	----	0.3	0.2	10.0	37.9	31.1	1.1
Maximum	43.0	47.8	19.0	13.4	----	----	4.3	27.6	42.9	46.6	49.3	47.1
Average	2.4	3.2	1.4	1.2	----	----	1.7	4.1	22.1	42.1	38.9	9.4
						Depth (feet)						
Minimum	1.0	0.9	0.9	0.9	----	----	0.8	0.8	0.8	1.7	2.6	1.5
Maximum	1.8	1.6	1.6	1.8	----	----	1.3	1.5	2.3	3.6	3.6	2.8
Average	1.4	1.2	1.2	1.3	----	----	1.1	1.1	1.5	2.5	3.1	2.2
						pH						
Minimum	7.4	7.4	7.6	7.6	----	----	7.5	7.4	7.2	7.0	6.9	7.1
Maximum	8.4	8.5	8.5	8.5	----	----	7.7	8.7	8.8	9.2	8.2	8.2
Average	7.9	7.8	7.9	7.8	----	----	7.6	7.8	7.8	7.7	7.3	7.5

Appendix Table 25. Monthly environmental data collected from Secesh River (RKm 609.4 from the mouth of the Salmon River) from August 1998 through July 1999.

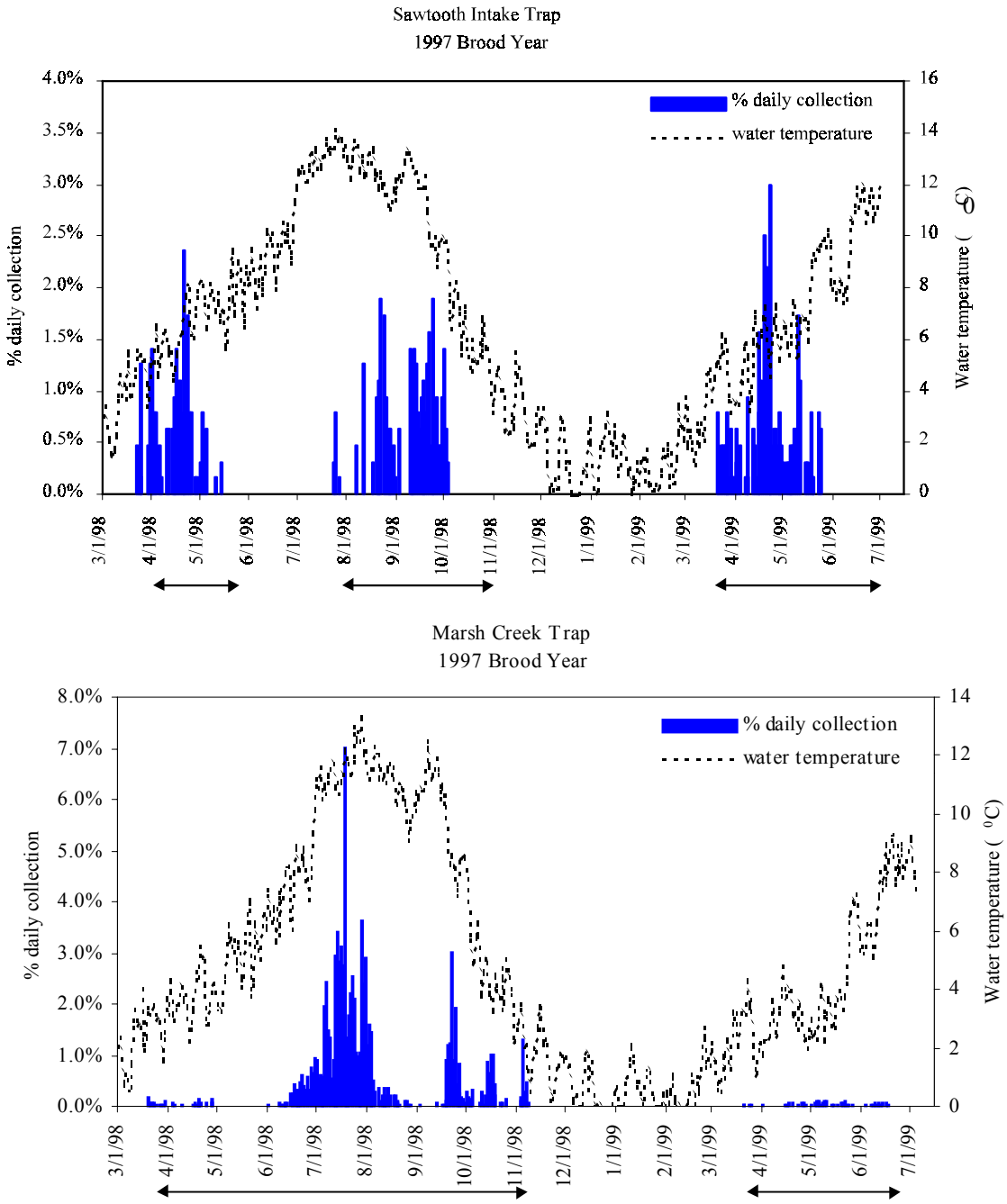
	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
						Temperature (°C)						
Minimum	8.1	4.9	0.1	0.0	----	----	----	----	0.6	0.0	1.9	4.1
Maximum	15.7	15.5	9.9	3.2	----	----	----	----	6.6	8.5	10.9	15.6
Average	12.1	10.2	3.7	0.7	----	----	----	----	2.1	3.4	6.1	10.4
						Dissolved Oxygen (ppm)						
Minimum	7.7	8.0	10.4	10.1	----	----	----	----	9.9	9.2	8.6	7.7
Maximum	11.1	12.5	14.2	14.2	----	----	----	----	11.3	11.3	10.7	10.2
Average	9.1	10.0	12.7	11.2	----	----	----	----	10.9	10.4	9.7	8.7
						Specific Conductance (µS/cm)						
Minimum	28.0	33.0	35.0	26.0	----	----	----	----	23.0	16.0	16.0	20.0
Maximum	39.0	43.0	42.0	42.0	----	----	----	----	28.0	28.0	22.0	31.0
Average	33.0	38.0	39.0	36.0	----	----	----	----	26.0	23.0	19.0	26.0
						Turbidity (ntu)						
Minimum	0.8	----	0.5	0.1	----	----	----	----	1.8	1.0	1.3	0.2
Maximum	48.7	----	48.6	39.4	----	----	----	----	18.4	42.8	42.0	10.5
Average	9.6	----	28.6	1.2	----	----	----	----	5.4	7.2	3.3	1.0
						Depth (feet)						
Minimum	0.8	0.5	0.5	0.5	----	----	----	----	1.9	1.6	2.8	1.3
Maximum	1.6	1.5	1.5	1.3	----	----	----	----	2.4	3.7	3.8	2.8
Average	1.1	0.9	0.9	0.8	----	----	----	----	2.1	2.2	3.4	2.0
						pH						
Minimum	7.0	7.0	7.0	7.1	----	----	----	----	6.9	6.5	6.6	6.8
Maximum	8.6	8.8	8.4	7.6	----	----	----	----	7.1	7.3	7.5	7.7
Average	7.6	7.5	7.3	7.3	----	----	----	----	7.0	6.9	6.9	7.1

Appendix Table 26. Monthly environmental data collected from South Fork Salmon River (RKm 609.4 from the mouth of the Salmon River) from August 1998 through July 1999.

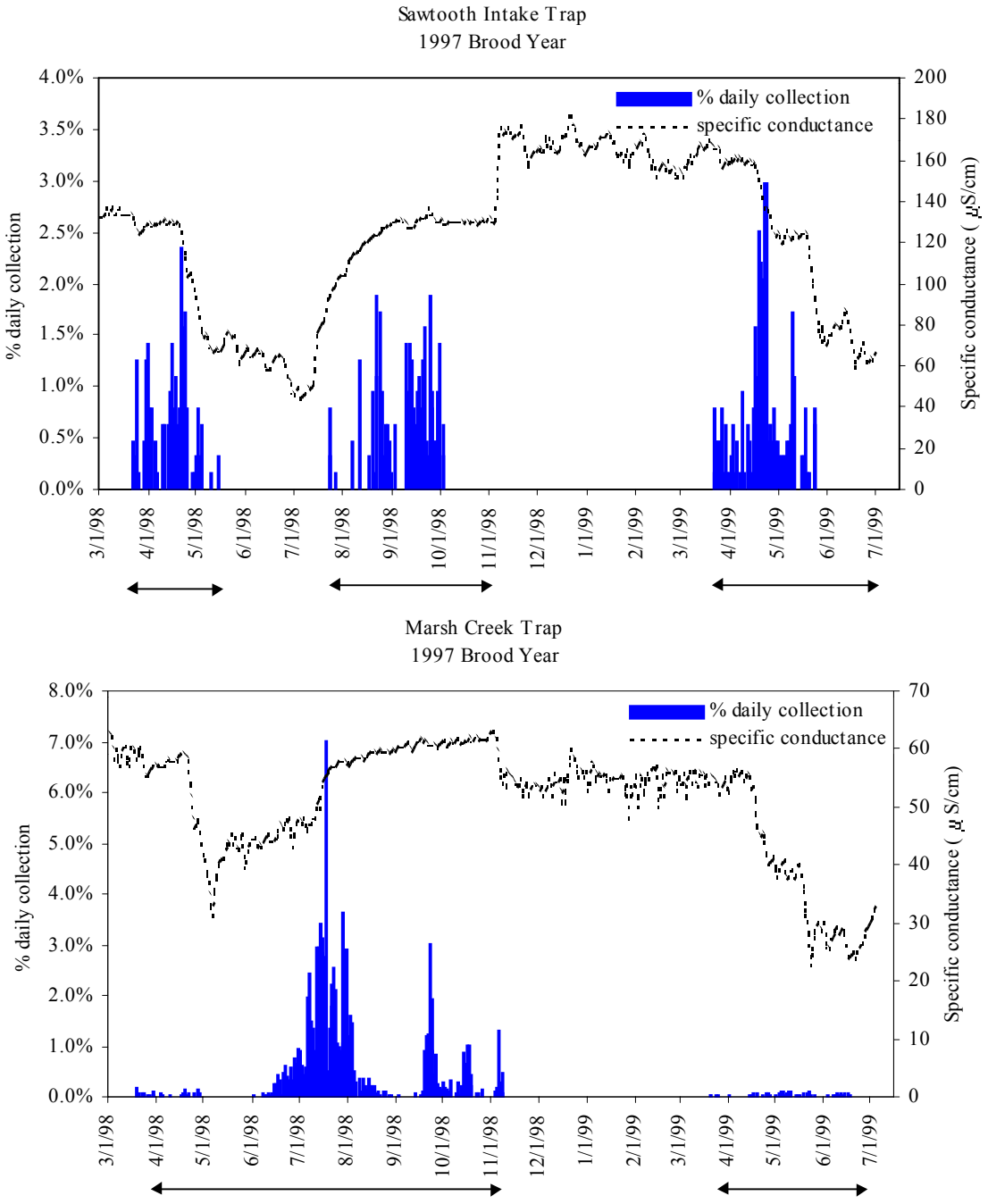
	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
						Temperature (°C)						
Minimum	8.4	6.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.3	2.3	4.7
Maximum	15.7	15.7	10.8	4.0	2.3	1.6	2.2	4.8	7.4	8.5	9.9	15.6
Average	12.3	11.4	4.6	1.5	0.2	0.3	0.4	1.3	2.8	4.1	5.8	10.5
						Dissolved Oxygen (ppm)						
Minimum	7.8	8.0	9.4	11.2	11.7	12.3	11.6	12.2	1.1	----	----	8.3
Maximum	10.6	11.8	13.2	12.8	13.3	14.0	14.1	14.2	12.9	----	----	10.4
Average	8.9	9.3	11.4	12.0	12.5	12.7	12.7	13.4	8.2	----	----	9.2
						Specific Conductance (µS/cm)						
Minimum	32.0	37.0	45.0	44.0	36.0	47.0	45.0	31.0	24.0	18.0	19.0	24.0
Maximum	49.0	50.0	56.0	59.0	66.0	59.0	62.0	51.0	42.0	34.0	25.0	40.0
Average	42.2	46.7	49.4	52.8	52.8	54.6	55.9	42.5	34.3	27.7	21.7	31.8
						Turbidity (ntu)						
Minimum	0.7	16.7	0.0	0.0	0.0	0.0	0.0	0.4	2.0	2.9	2.6	0.3
Maximum	49.9	44.5	44.5	10.5	9.9	31.4	2.6	18.6	30.6	48.3	45.2	38.2
Average	14.2	24.8	16.2	1.1	0.9	0.3	0.3	3.4	7.2	10.3	5.8	3.3
						Depth (feet)						
Minimum	0.6	0.3	0.3	0.1	0.3	0.0	0.0	0.2	0.4	1.2	1.6	0.7
Maximum	1.4	1.1	1.0	0.8	1.9	1.7	1.8	1.2	1.9	3.5	3.0	1.7
Average	1.0	0.7	0.6	0.4	1.1	0.8	0.6	0.7	1.2	2.1	2.3	1.2
						pH						
Minimum	7.3	7.3	7.3	7.2	7.3	7.4	7.5	7.3	7.2	6.7	6.7	6.9
Maximum	8.4	8.4	8.1	7.7	7.7	7.7	7.9	8.0	8.0	8.3	7.9	7.8
Average	7.6	7.6	7.4	7.4	7.4	7.5	7.6	7.6	7.5	7.3	7.0	7.3

Appendix Table 27. Monthly flow information from August 1998 through July 1999 in cubic feet per second (cfs) for various sites in the Salmon River drainage in Idaho. These data were provided by the U.S. Geological Survey and are cited as provisional data subject to revision.

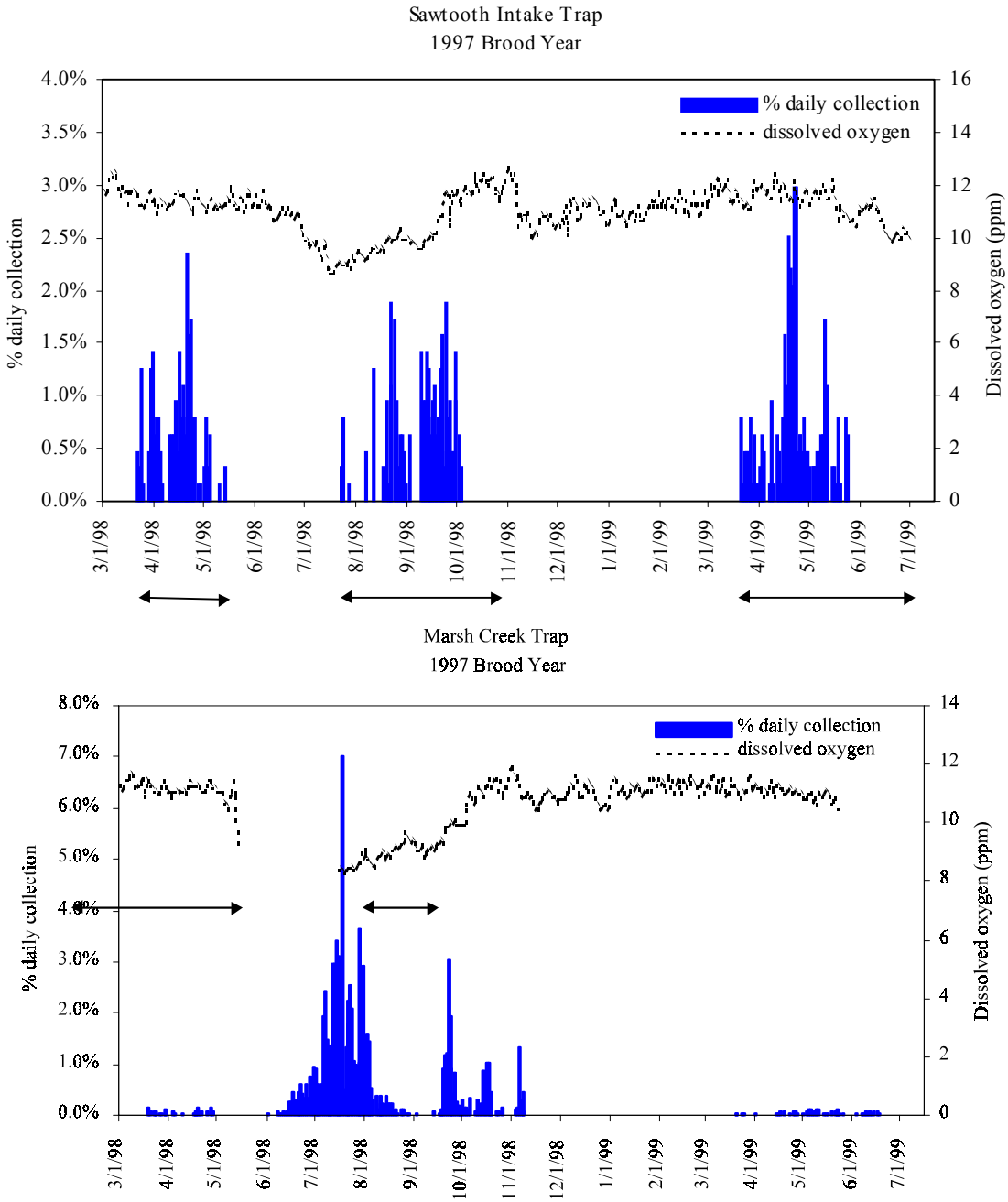
Flow	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Station 13295000--Valley Creek at Stanley, ID												
Mean	110	100	90	92	94	90	95	99	201	574	897	381
Min	76	72	75	70	63	78	89	79	97	315	617	208
Max	181	181	109	120	121	110	109	143	427	1,220	1,190	639
Station 13302500--Salmon River at Salmon, ID												
Mean	1,460	1,259	1,452	1,503	1,267	1,204	1,198	1,362	1,801	4,169	8,204	3,103
Min	1,040	1,000	1,250	1,380	700	950	1,000	1,160	1,270	2,110	5,130	1,700
Max	2,330	1,610	1,540	1,620	1,600	1,400	1,370	1,810	2,820	10,800	11,900	5,400
Station 13310700--South Fork Salmon River near Krassel Ranger Station, ID												
Mean	228	188	155	171	169	162	157	342	756	1,990	2,752	745
Min	167	156	138	141	85	130	130	170	307	844	1,580	320
Max	382	372	189	240	240	185	200	836	1,570	4,890	3,880	1,520
Station 13314300--South Fork Salmon River at mouth near Mackay Bar, ID												
Mean	916	739	606	658	691	600	611	1,212	2,252	7,014	11,112	3,105
Min	667	613	525	529	213	500	522	674	1,060	2,810	6,540	1,430
Max	1,460	1,400	745	1,030	1,130	705	795	2,360	4,730	17,800	15,300	6,250
Station 13317000--Salmon River at White Bird, ID												
Mean	6,391	5,282	5,106	5,411	5,052	4,927	4,609	8,198	13,482	34,381	53,753	16,312
Min	4,740	4,390	4,840	4,770	2,090	4,220	4,140	4,940	7,690	16,300	31,800	8,340
Max	9,660	7,550	5,540	6,690	7,530	5,990	5,450	16,000	24,300	80,900	71,100	30,500



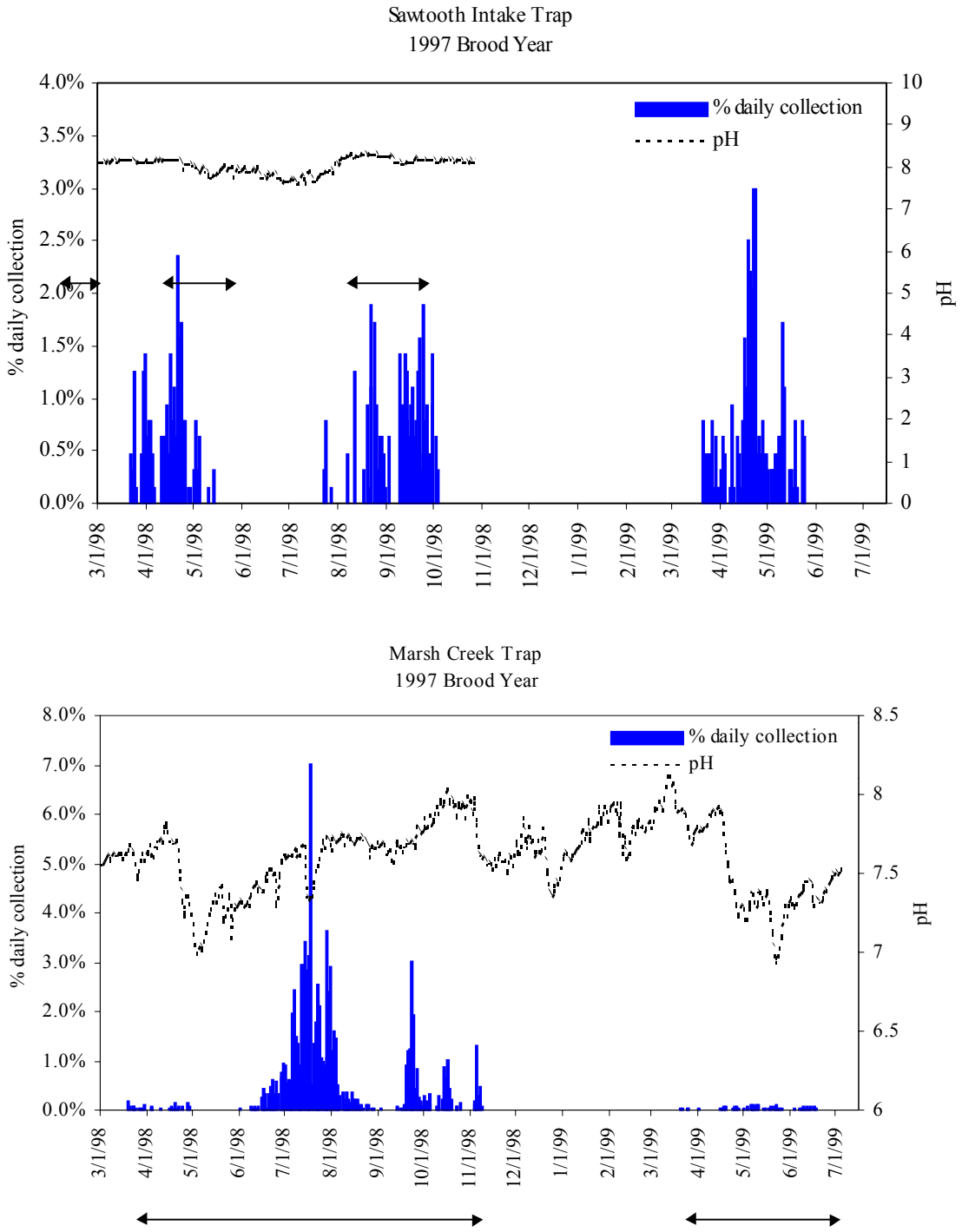
Appendix Figure 1. Daily passage of wild chinook salmon fry, parr, and smolts at two migrant traps, expressed as percentages of total collected, and plotted against average daily water temperatures measured near traps. Arrows indicate trap operation time.



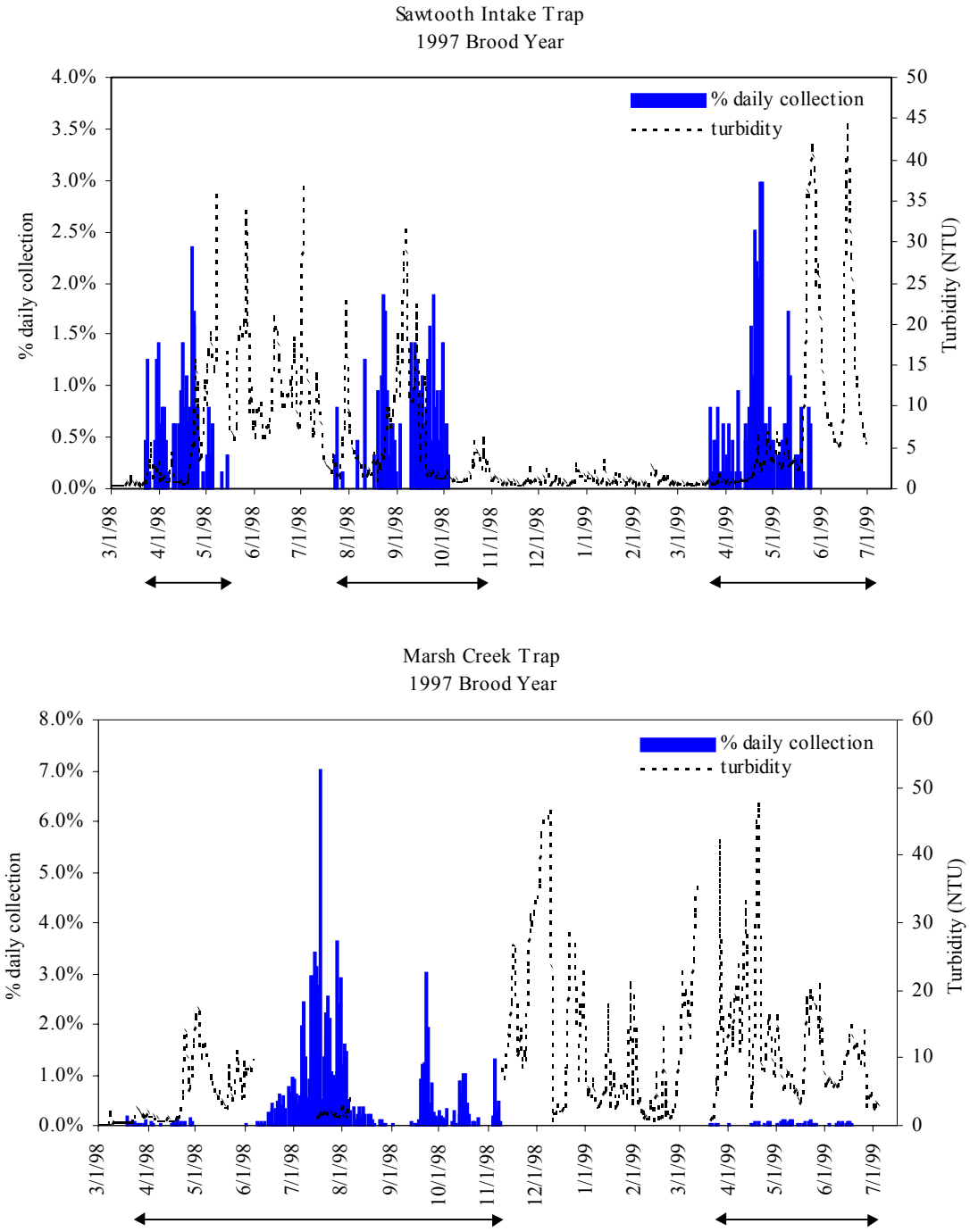
Appendix Figure 2. Daily passage of wild chinook salmon fry, parr, and smolts at two migrant traps, expressed as percentages of total collected, and plotted against average daily water conductivity measured near traps. Arrows indicate trap operation time.



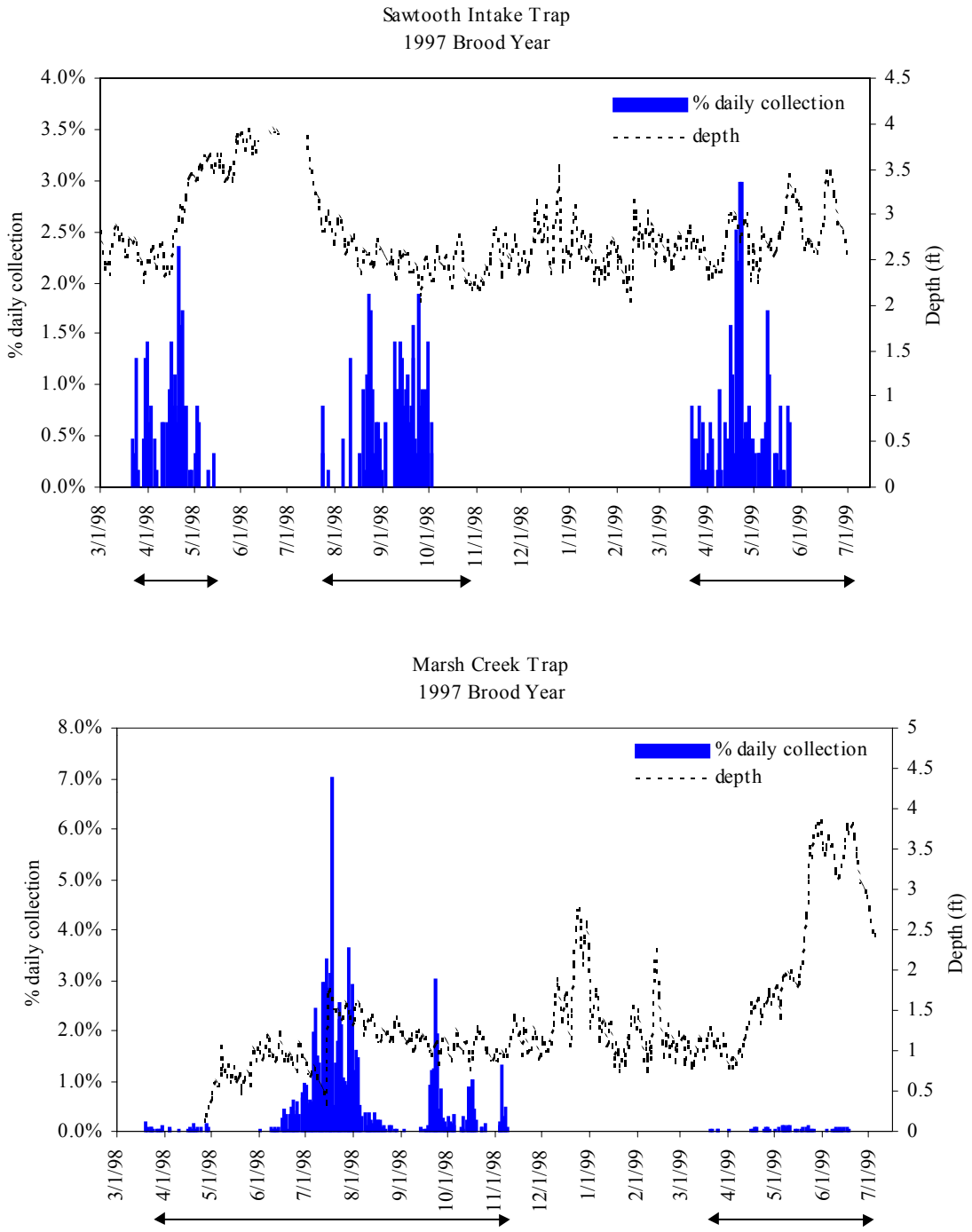
Appendix Figure 3. Daily passage of wild chinook salmon fry, parr, and smolts at two migrant traps, expressed as percentages of total collected, and plotted against average daily dissolved oxygen measured near traps. Arrows indicate trap operation time.



Appendix Figure 4. Daily passage of wild chinook salmon fry, parr, and smolts at two migrant traps, expressed as percentages of total collected, and plotted against average daily pH measured near traps. Arrows indicate trap operation time.



Appendix Figure 5. Daily passage of wild chinook salmon fry, parr, and smolts at two migrant traps, expressed as percentages of total collected, and plotted against average daily turbidity measured near traps. Arrows indicate trap operation time.



Appendix Figure 6. Daily passage of wild chinook salmon fry, parr, and smolts at two migrant traps, expressed as percentages of total collected, and plotted against average daily water depth near traps. Arrows indicate trap operation time.